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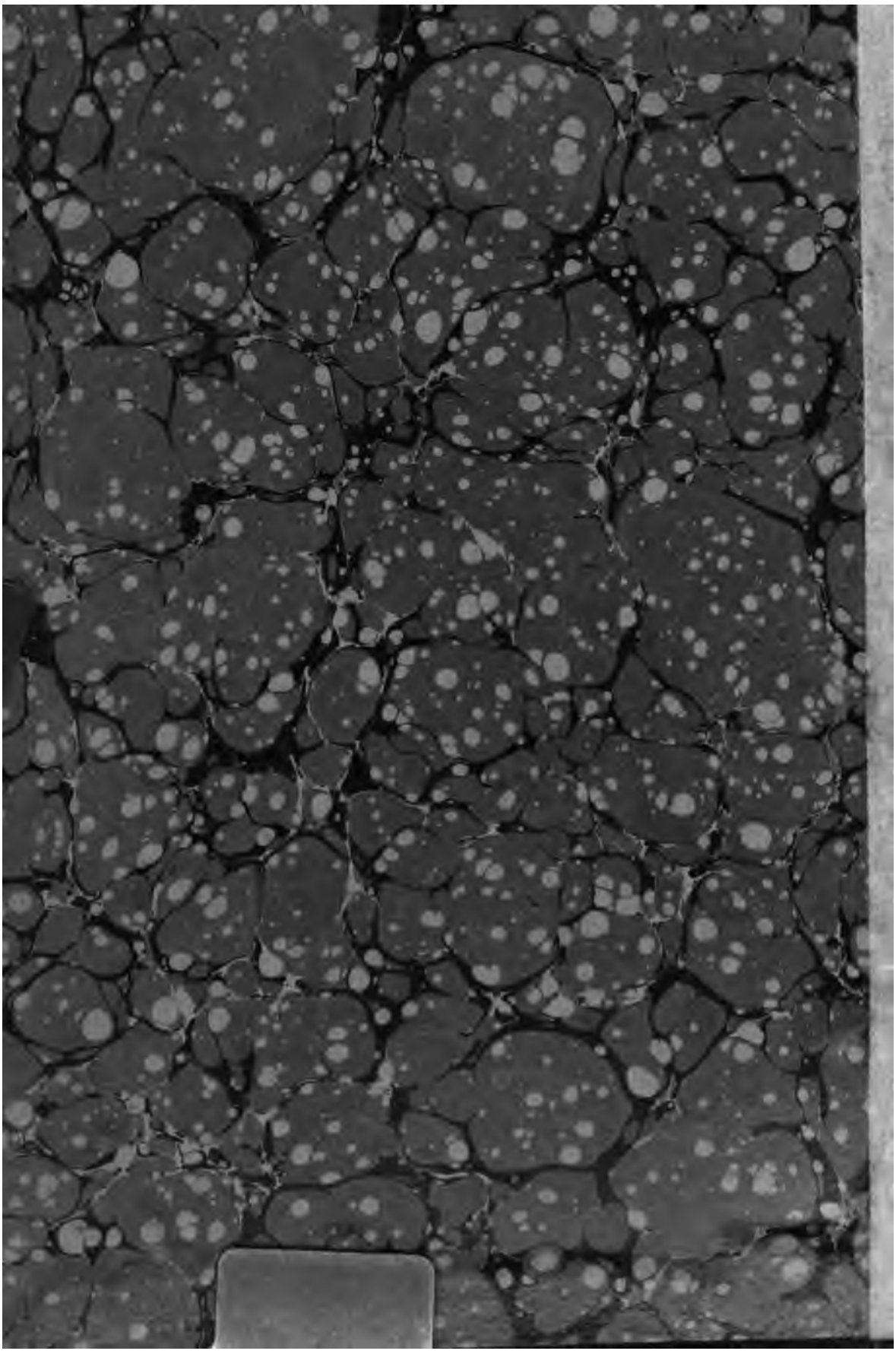

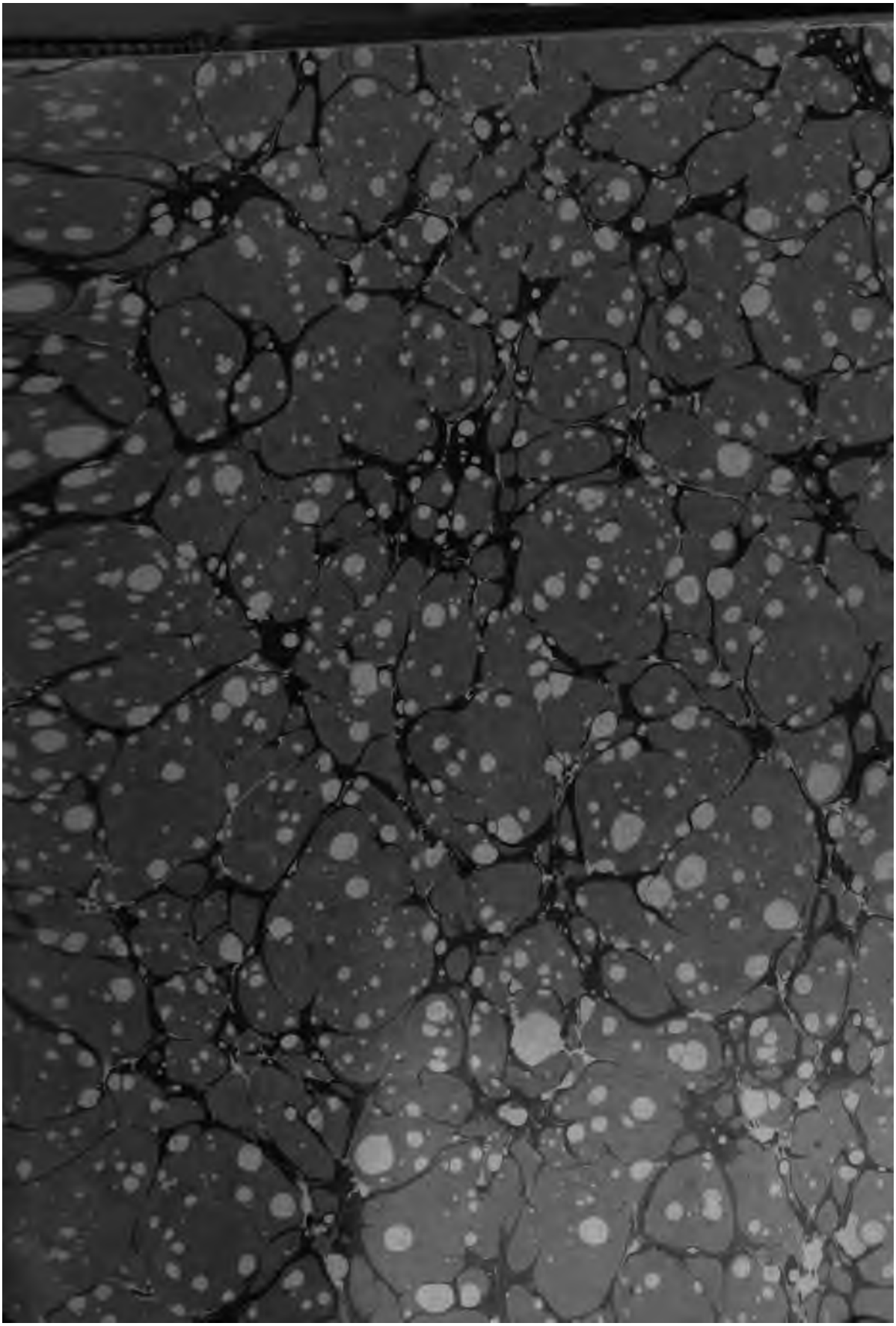

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## ZOOLOGY

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PROCEEDINGS

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# Studies on Ciliate Infusoria

BY

N. M. STEVENS

WITH SIX PLATES

*Issued May 4, 1901*

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1901

# STUDIES ON CILIATE INFUSORIA.[1]

BY N. M. STEVENS.

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II. BOVERIA SUBCYLINDRICA, GEN. ET SP. NOV..... 20

THESE forms were discovered by Dr. F. M. McFarland in the respiratory tree of *Holothuria californica* Stimp., at Pacific Grove, California, in the summer of 1893. In June, 1898, the working out of their structure and general biology was assigned to the author of this paper as a problem in cytology. The number of new and interesting points which came out in the course of the study seems to warrant the present publication.

The work on which the paper is based was done in the Hopkins Seaside Laboratory at Pacific Grove, and in the Histological Laboratory of Leland Stanford Junior University, between June 1, 1898, and January 1, 1900, under the direction of Dr. McFarland, to whose suggestions and coöperation is to be credited whatever of value the paper may contain.

My acknowledgments are due to the Directors of the Hopkins Seaside Laboratory, Drs. Gilbert and Jenkins, for the use of an investigator's room and for all possible laboratory assistance and privileges during the summer of 1899.

*Technique.*—The respiratory tree was removed from the living holothurian, plunged into the fixing fluid, and later

[1] Thesis presented to the faculty of Leland Stanford Junior University, May 25, 1900, in candidacy for the degree of Master of Arts.

washed, and hardened in alcohol. Small pieces were imbedded in paraffine in the usual way, and sections 5 to 7 μ thick were cut and mounted in series. For *in toto* preparations, portions of the respiratory tree were stained, washed, and run into glycerine or through alcohols, followed by clove oil, teased upon the slide to free the infusoria from the respiratory membrane, and mounted in glycerine, glycerine jelly, or balsam.

A large number of fixing agents were tried: picro-acetic, picro-sublimate-acetic, Gilson's fluid, sublimate-acetic, iridium chloride-acetic, Flemming's strong and weak solutions, Vom Rath's solution, platinum chloride-acetic, Hermann's fluid, absolute alcohol, absolute-acetic, palladium chloride, Rabl's fluid, bichromate-osmic, and osmic vapor.

Hermann's fluid gave the best results, though sublimate-acetic, absolute-acetic, Boveri's picro-acetic, Flemming's and Vom Rath's solutions proved quite satisfactory, and osmic vapor was especially valuable for temporary *in toto* preparations in the study of division stages.

Peptone and pepsin solutions, bichromate of potash (one to three per cent.), formalin (one-tenth to one per cent.) and fresh water were employed as macerating agents; of these, potassium bichromate (two per cent.) was found to be of greatest value in revealing and isolating the internal fibre structures of *Licnophora*.

The principal stains used were Delafield's hæmatoxylin, dahlia, bismark brown, thionin, methylen blue, acid fuchsin, borax carmine, alum carmine, picro-carmine, Mayer's paracarmine, light green, safranin, Heidenhain's iron-hæmatoxylin, rubin, and ruthenium red. For fresh material picro-carmine and alum carmine gave the best results; borax carmine, paracarmine, light green, and safranin were useful in the study of fixed material *in toto;* for sections no other stain was at all comparable to Heidenhain's iron-hæmatoxylin following Hermann's fixing fluid, and used either alone or in combination with rubin or with ruthenium red.

## I. Licnophora macfarlandi,[1] sp. nov.

PLATES I-III; PLATE VI, FIGS. 68-82.

*Historical Summary.*—In 1862, Claus (1862) described a Trichodina-like infusorian, parasitic on the medusa *Cladonema*, and in 1865 Meyer and Moebius (1865) found a similar form on *Æolis alba*, in the Bay of Kiel. That these forms belong to the genus *Licnophora* is evident from the descriptions and figures, but they have not been identified as to species.

In 1866, Auerbach discovered and Cohn (1866) described and named *Trichodina auerbachii*, an infusorian found on *Doris muricata* at Helgoland. The species was characterized by an elongated body, by separation of the attachment disc from the oral disc by a narrow neck, and by a left hand peristomal spiral.

In 1867, Claparède (1867) created the genus *Licnophora* for a new species, *Licnophora cohnii*, found on an annelid, *Psyrmobranchus protensus*, in the Bay of Naples, and transferred Cohn's *Trichodina auerbachii*, which he also found on *Thysanozoon tubercula*, to this genus as *Licnophora auerbachii*.

In 1884, Gruber (1884*a*) named a third species, parasitic on the dermal branchiæ of *Asteriscus*, in the Gulf of Genoa, *Licnophora asterisci*. This species Gruber describes as very near to *Licnophora auerbachii*.

Fabre-Domergue (1888) regards these three species as identical. He says: "Or, je ne crois pas que l'habitat suffise pour faire séparer deux formes parasites qui ne présentent aucune différence d'organisation, et comme j'ai eu l'occasion d'étudier des *Licnophora* fixées à des *Syllis* et à des *Ophiothrix*, et identiquement semblables, je crois que l'on peut, jusqu'à nouvel ordre, réunir sous le premier nom de *Licnophora auerbachii*, toutes les espèces connues."

Bütschli (1889) mentions Fabre's opinion, but says that there are probably two or three species.

[1] Specific name given out of respect to Dr. F. M. McFarland, Associate Professor of Histology, Leland Stanford Junior University.

Wallengren (1894) holds that until the genus is more carefully studied three species must be retained: *Licnophora auerbachii* Cohn, *Licnophora cohnii* Claparède, *Licnophora (auerbachii)* Fabre, the latter species not being identical with the one described by Cohn. The form which Wallengren has worked upon, he finds upon *Doris muricata* and regards as identical with that found on the same host by Auerbach and Cohn, and by Claparède on *Thysanozoon tubercula*. *Licnophora asterisci*, from Gruber's description and figures, he identifies with *L. auerbachii;* but Fabre's (1888) account of the rudimentary velum and ciliary membranes of the attachment disk and of the peristomal membranellæ lead him to think that he (Fabre) was working on a different species. Claparède's comparison of the two forms which he describes leaves little doubt that *L. auerbachii* and *L. cohnii* are distinct species.

These forms are all exclusively marine and occur as ectoparasites or commensals on gills or tentacles of various nudibranchs, annelids, etc.—*Cladonema*, *Æolis*, *Aplysia*, *Doris*, *Psyrmobranchus*, *Syllis*, *Thysanozoon*, *Asteriscus*, *Ophiothrix*.

Two fresh water forms have been described: the first, *L. setifera*, by Maskell (1886), as occurring in New Zealand; the second, as *L. europæa*, by Garbini (1898) of Verona. A comparison of the figures and descriptions given by the two authors shows many points of mutual similarity, but nothing whatever of the characteristic features of *Licnophora*. Bütschli (1889) alludes to *L. setifera* Mask. as a doubtful species, and both it and *Licnophora europæa* Gar. should be carefully studied before their validity as species of *Licnophora* can be recognized.

Brief morphological descriptions of the various species of *Licnophora* have been given by Cohn (1866), Claparède (1867), W. Saville Kent (1881–1882), Gruber (1884*a*), Fabre-Domergue (1888), Bütschli (1889). The only extended cytological study of *Licnophora*, including the first account of its division phenomena, was published in Swedish by Hans Wallengren, in 1894. The study was

made with a view to confirm Bütschli's theory, that *Licnophora* is an intermediate form between hypotrichous and peritrichous Ciliata. For this purpose, careful observations were made of both anatomical and cytological structure, special attention being given to the method of division of *Licnophora*. The results of Wallengren's observations lead him to discard Bütschli's theory and to look upon *Licnophora* as a highly specialized form of the Peritricha. Its relationship to other genera of peritrichous infusoria is, in his opinion, still an open question.

*Habitat.*—The species of *Licnophora*, which is the subject of this paper, is an entoparasite or commensal of *Holothuria californica*. It occurs in large numbers in the respiratory tree of the holothurian, and has not yet been found as an ectoparasite on the same or other hosts in Monterey Bay. When the respiratory tree, just removed from the holothurian, is examined under a low power, the *Licnophoræ* are seen attached to the inner epithelial surface of the transparent membrane, in company with a second ciliate infusorian to be described in the second part of this paper.

The number of both forms varies greatly in different individuals. Out of the many holothurians examined (one hundred or more), only one was without these parasites. One contained only the second form; a few had only a few specimens of *Licnophora;* but an abundance of both was the rule. The material was much richer in 1899 than it was in 1898. The infusoria occurred in largest number in the peripheral branches of the respiratory tree, and in general at the tips of the finger-like subdivisions.

The habitat of this species is peculiarly fortunate for cytological study on account of the abundance of material and the ease with which large numbers of individuals can be fixed, imbedded, sectioned, stained, and mounted in series.

*General Description.*—Like the other species, *Licnophora macfarlandi* has an elongated body consisting of three distinct regions—an oral disc, an attachment disc, and

a connecting stalk or neck. The attachment disc is very constant in form and size, while the oral disc is continually varying in outline; the stalk is exceedingly contractile and so extensible that at times it reaches the length of one-third that of the oral disc, and again contracts so as to bring the two discs in contact, tangent to each other.

In swimming the two discs are at right angles to one another, but at rest they most often lie in parallel or oblique planes (figs. 2, 3 and 68).

In fixed specimens the length of the body, measuring across both discs without cilia, varies from 67 $\mu$ to 96 $\mu$. One very large specimen with stalk much extended, probably approaching division, measured 180 $\mu$ alive (fig. 69). A slight general contraction of all parts of the body occurred with all methods of fixation, least with formalin.

In the living respiratory tree the infusoria are seen attached to the membrane and either swinging the oral disc about now this way, now that, the attachment disc being fixed; or more commonly rotating the whole body on an axis passing through the center of the attachment disc at right angles to the plane of attachment, in a direction opposite to that of the oral spire (fig. 70).

When set free in a watch-glass or on a slide the infusoria swim very rapidly, attachment disc forward, with two characteristic movements: (1) a rotary and a forward movement combined, the peristomal cilia producing the rotary movement and the ciliary membranes of the attachment disc the forward movement; (2) an occasional more or less periodic darting forward, in which contraction and expansion of the stalk seem to be the motive power. They also glide along the cover-glass as they rotate when attached, and have been seen to run over a portion of the respiratory tree with the cilia of both discs downward, showing something of the agility of *Trichodina pediculus*.

*Structure and General Biology.—Licnophora* like most of the Ciliata has a delicate structureless pellicula (Schultze), not distinguishable in life, but readily separated from the cytoplasm by macerating fluids and by many fixing

agents. The ectoplasm is clearly marked only at the margin of the attachment disc, between its cuticula and fibre layers, and within the triangular basal portion of the oral band, where it is either homogeneous or very finely granular (fig. 9, $s^1$). The entoplasm is coarsely alveolar in both discs and more finely alveolar in the neck.

*Oral Disc.*—The oral disc is irregularly circular in outline, having a projection on the left side opposite the buccal cavity (fig. 3). The ventral side is depressed centrally and posteriorly (fig. 3); the dorsal side convex laterally and posteriorly,[1] but continuous with the neck anteriorly (fig. 2). The width of the disc varies from 33.5 $\mu$ to 57 $\mu$ in fixed material, and was 72 $\mu$ in the large living specimen cited above (fig. 69).

The mouth and pharynx form a pear-shaped cavity extending obliquely nearly three-fourths of the width of the body, its greatest width being about three-fifths of the length. The external opening, generally oval, is very variable in form and size in the living animal, as indeed are the whole mouth and pharynx. The lower lip is merely a transparent fold of pellicula, while the upper lip is made thick and heavy by the ciliary band which twists and passes under it to form the roof of the pharynx (figs. 3, 4 and 9).

The oral ciliary band begins just above the pharynx on the left side, curves about the posterior extremity and right side, and passes with a twist under the upper lip of the mouth, where it broadens out and covers the roof of the pharynx into which its cilia descend (figs. 3, 4, 9 and 17). The band is made up of about one hundred and twenty-five transverse rows of fine long cilia which are usually twisted together in action so as to appear under low power as so many stout membranellæ, but under Abbé homogeneous apochromatic oil immersion 1.5 mm., oc. 8, the individual cilia are plainly seen in the living specimen, hundreds of them in each row forming a flat brush or a

[1] I have used the terms *anterior* and *posterior* with reference to the orientation of the animal when it swims: the attachment disc is almost always forward and is therefore the anterior and the other the posterior end.

stout twist (figs. 4, *g* and 71). The transverse width of these flat brushes, i. e., the width of the band, is least at the beginning of the band (fig. 72) and is increased one-half or more in the pharynx, the average width outside of the mouth being 10 $\mu$ in large living specimens. The cilia of the several rows on the left side are most often seen untwisted in the living animal at rest; while those on the right side, where the band turns toward the mouth, are often divided, one portion extending outward, the other curving toward or into the mouth. The cilia are approximately equal in length throughout the band, 30 $\mu$ in living and 18 $\mu$ in fixed material. Wallengren describes the oral spire of *L. auerbachii* as consisting of stout membranellæ set in a "Peristomalrinne," each membranella being broad at the base and tapering out to a sharp point. These tend to split up into fine fibrillæ, long on the ventral side and short on the dorsal.

The most constant action of the oral cilia is a strong stroke of the twisted rows toward the mouth, producing a current in that direction, and rotating the body in the opposite direction. In feeding, this movement alternates with a second, in which the cilia of the posterior half of the peristome are more or less untwisted and suddenly clapped down on the ventral surface of the disc, driving food before them toward the mouth.

In sections fixed in Hermann's or Flemming's fluid and stained with Heidenhain's iron-hæmatoxylin, the oral band is seen to have a complicated internal structure. At the base of each row of cilia is a deeply stained basal band whose ends are connected by fine fibres with an internal, deeply staining fibre. A cross-section of the band presents a triangular appearance with deeply stained basal band and lateral fibres enclosing a dense homogeneous or finely granular portion. The proportions of the triangle vary greatly from the beginning of the band to its end in the pharynx (fig. 73).

Tracing these fibres back from the mouth-region around the peristome into the neck, their origin is found in a stout, longitudinally striated, deeply staining fibre, which arises

from a branching base at the center of the attachment disc and extends diagonally through the neck to the beginning of the oral band, where it gives off a branch to each end of each basal band. The first branches given off are coarse and oblique, the later ones fine and nearly perpendicular to the basal fibre (figs. 4, 17, $f^1$, and 74).

This stout neck fibre with its oral prolongation and branches is somewhat anisotropic, fibrous, and contractile. The only clearly differentiating stain found for it is iron-hæmatoxylin; second to this was Mayer's picro-carmine, the material being left in the stain for forty-eight hours. In macerations, the fibre with its various branches is the most resistant part of the body. Potassium bichromate (one to three per cent.) will in a few seconds, aided by slight tapping on the cover-glass, dissolve away the alveolar entoplasm and the pellicula, leaving the inner layers of the attachment disc with cilia, the neck fibres and the oral band with cilia, the skeleton of the animal, as it were (fig. 17). Similar results were attained with pepsin and peptone solutions, one-tenth per cent. formalin, and even with fresh water. The neck fibre is faintly visible in life, and is plainly seen in any macerating or fixing fluid before the cilia of the attachment disc and pharynx cease to vibrate. These facts clearly demonstrate that the fibre and its divisions so plainly shown in iron-hæmatoxylin stained sections are not artifacts.

Johnson (1893) describes a fibre (first mentioned by Brauer (1885) ) to which he ascribes a contractile or perhaps a coördinating function, connecting the roots of the oral membranellæ of *Stentor*. This structure is probably homologous with that of *Licnophora* but less complex. Schuberg (1886) describes a "Peristomband" and "Querband" in *Bursaria truncatella* as homogeneous (Bütschli says fibrous), and of ectoplasmic origin, while the fibres of *Stentor* and *Licnophora* are fibrous and entoplasmic.

The neck or stalk of the infusorian is flattened dorsoventrally, especially when extended. In contraction it is crossed by transverse wrinkles and deep furrows, both

dorsally and ventrally (figs. 2 and 3). On the ventral side there is a deep longitudinal groove extending nearly to its center, and from the border of the attachment disc to the left hand end of the external opening of the mouth (fig. 3, *h*; and cross-section, fig. 7, *h*) (Not the "Peristomalrinne" of Wallengren). Just dorsal to this groove in the entoplasm lies a fibre smaller than the one described above, attached to the oral band in the roof of the pharynx, running aborally a little to the right of the larger fibre, crossing and extending to the margin of the cup on the left side (figs. 4, 5, 17, 75, $f^2$).

*Attachment Disc.*—Structurally there may be distinguished in this disc, which has the form of a shallow thick-walled cup, four distinct layers. The inner, or cuticular layer, bounded at the margin by the inner row of cilia, is finely granular in life, and stains deeply with iron-hæmatoxylin. The second layer is homogeneous or possibly very finely granular and does not stain; this is the only clearly differentiated layer of ectoplasm in *Licnophora*, and extends only to the outer margin of the cup. The third layer is composed of coarse, deeply staining branches of the axial neck fibre, interwoven and ending abruptly between the basal bodies of the first and second rows of cilia (figs. 4, 5 and 75). External to this fibre layer on the left side terminates the smaller neck fibre, with its stout branches running to the ventral margin of the cup (fig. 5). The fourth, or outer layer of the cup consists of coarsely alveolar entoplasm continuous with that of the neck and oral disc, and is covered with the general body pellicula.

On the rounded margin of the cup are four closely set rows of cilia, regularly graded in length from within outward (8 $\mu$, 16 $\mu$, 24 $\mu$, 30 $\mu$) (figs. 17 and 69). The cilia are usually united into four concentric membranes with more or less deeply fringed edges, but a part of them are often seen separated in the living animal, and in fresh material treated with potassium bichromate or picro-carmine the cilia are always distinct. With a high power (Abbé

hom. ap. im. 1.15 mm.) the individual cilia can be traced from the base to the edge of each membrane, either in living or in fixed material (fig. 3, $m^1$, $m^2$, $m^3$, $m^4$).

Each individual cilium arises from a minute, clearly marked oval basal body about .2 $\mu$ in diameter, embedded in the ectoplasm immediately beneath the pellicula, about .5 $\mu$ apart in the rows and .8 $\mu$ from the adjacent row (figs. 4, 6, 13, 14, 17). These basal bodies are especially well brought out by iron-hæmatoxylin staining and are in every respect comparable to those described for ciliated cells of Metazoa by Lenhossèk (1898), Henneguy (1898), Peter (1899), and others.

The movement of the membranes is a rhythmical wave-like vibration, starting at their base, the four membranes waving in unison, the strongest and most constant movement being on the left ventral side. The inner membrane is sometimes seen tightly clasped upon the material to which the animal is attached, while the other three and the velum vibrate in unison. As these membranes are in constant motion in life, and are the last part of the body to cease moving, the various phases of their vibration are often beautifully preserved in fixation (fig. 8). No such lack of coördination as Wallengren describes was observed when the membranes were more or less split up into cilia or groups of cilia.

In attempting to isolate the cilia, as has been done for the ciliated cells of the alimentary tract of *Anodonta* by Peter (1899) and others, the attachment disc was several times severed from the oral disc at different points along the neck. In these cases, the disc swam forward in the water or moved along the glass exactly as under normal conditions. This, together with the fact that the cilia vibrate after the pellicula and the general body entoplasm are nearly or quite dissolved away by macerating agents, may be cited as additional evidence that the kinetic center of ciliary motion is to be found in the basal body or in the basal body plus the cilium.

Surrounding the outer border of the cup just without the insertion of the outer row of cilia is the so-called velum of Fabre-Domergue (1888). In the living *Licnophora* it appears as a delicate homogeneous membrane 8 μ to 10 μ in width (fig. 76, $v^1$, $v^2$), made up of two overlapping parts as figured by Wallengren for *L. auerbachii*. In radial sections of the disc the velum appears as a loop of pellicula, often, but not always, containing finely granular cytoplasm (figs. 4, *v*, 13, 14, *v*). The velum may function when the animal is attaching itself to its host to secure more perfect suction, but it is certainly not closely pressed against the host afterwards, as such pressure would prevent the constant free movement of the ciliary membranes. No definite movement of the velum itself has been observed, except a constant vibration in unison with the ciliary membranes.

Connected with the smaller neck fibre at its outer end and apparently moved by its contraction is a vibratile membrane (figs. 2, *e* and 3, *e*), consisting of an extensible fold of pellicula reaching from the tip of the fibre in the left hand margin of the cup along the left margin of the neck groove to a point near its termination in the mouth. The membrane is raised and extended by an outpushing and elevation of the extremity of the fibre, given a forward flapping movement as the fibre is drawn inward and downward, and disappears from view, being somewhat contracted laterally, and folded forward over the ventral neck groove (fig. 77, *a*, *b*, *c*, *d*). When the extremity of the fibre (fig. 77, *b*) reaches its highest point, the membrane is very tense and its margin is a strong definite line; as the fibre is lowered, the margin becomes indistinct and the whole membrane vanishes. The appearance and disappearance of the membrane is seen both when the infusorian is attached and feeding, and when it is swimming. The movement is quite rhythmical but the rate varies greatly at different times, being much greater in swimming. When the *Licnophora* is at rest, this membrane is often extended for some time, either motionless or waving slowly, sometimes at one end, sometimes at the other, and again along the whole edge. The vibration certainly produces a current

along the neck groove toward the mouth, and the greater rapidity of its vibration when the animal is swimming may indicate some locomotor function.

*Vacuoles.*—This species has no contractile vacuole, agreeing in this respect with the forms described by Claparède, Fabre-Domergue, Gruber, and Wallengren, while Claus and Cohn figure such a vacuole on the right side of the body in the mouth region. Food masses enter the entoplasm at the extremity of the conical pharynx, pass posteriorly and accumulate in the region posterior to the mouth (figs. 2 and 3), though in some full fed specimens a few food vacuoles are seen on the right side above the mouth; but they never pass into the neck or attachment disc, which are therefore more transparent than the oral disc. The animal is exceedingly well provided for in the way of apparatus for carrying food particles to its mouth—oral cilia, ciliary membranes, vibratile neck membrane and ventral neck groove all contributing to that end. No anus has been detected. The food masses consist of diatoms, other infusoria, and of what appear to be either leucocytes or loosened epithelial cells from the host. The whole posterior half of the oral disc is often filled with yellowish brown diatom masses; shells of navicula, extending half way across the disc, are frequently seen (fig. 2).

*Nuclei.*—In the adult form of this *Licnophora* there is found to the right of the axial neck fibre, very near its point of union with the base of the attachment cup, a small spherical body which stains deeply with iron-hæmatoxylin, but destains much more easily than the neck fibres or macronuclei and does not readily take nuclear stains. Its diameter is about 2 $\mu$ but increases to 3 $\mu$ in division stages. Its structure is homogeneous. Its behavior in division, increasing in size and becoming less stainable, as do the micronuclei of *Stentor*, as described by Johnson (1893), leads one to think that this body is a micronucleus, but the phenomena of conjugation which should establish its nature and function have not yet been observed (figs. 4, 7, 13, 14, $n^2$).

The macronuclei are from twenty-five to thirty in number and form a somewhat broken chain, extending around the attachment disc, through the neck on the left side, around the oral disc just within the band, and across above the mouth to meet the left hand portion of the chain; one or two are usually found on the right side of the neck (fig. 18). The nuclei are in most cases entirely separate, but some specimens have groups of three or four within a common membrane, probably a case where complete separation has not yet taken place after division (fig. 78).

With most stains the nuclei appear to be homogeneous, but with iron-hæmatoxylin considerably destained, they frequently show coarse granules (fig. 79). Stained with safranin, some appear homogeneous, while others contain irregular, deeper staining masses (fig. 80). Picro-carmine on fresh material shows granules, threads, and occasionally a vacuole (fig. 81). The nuclei vary considerably in size in the same and in different individuals (6 $\mu$–7.5 $\mu$, 3.7 $\mu$–4.5 $\mu$, 2.25 $\mu$–6 $\mu$, diameter of nuclei of three specimens). They vary in form from spherical to oval or elliptical and after fixation are often irregular in outline. The largest measurement (6 $\mu$–7.5 $\mu$) was for formalin (one per cent.) fixation followed by picro-carmine stain.

*Division Phenomena.*—The division stages, as observed for this species of *Licnophora*, agree in general outline with those of *L. auerbachii* as given by Wallengren. There are, however, many differences in detail, and more abundant material has furnished a more complete series of stages.

*Changes in Form.*—The first indication of approaching division is increased size (fig. 18), the change being most marked in the neck, which is shorter and thicker, and in the oral disc, which is enlarged in all diameters. In the early stages (figs. 19 to 21) there is an increase in size in all directions, the attachment disc changing but little and the neck becoming so broad and thick as to be hardly distinguishable. The whole body now increases rapidly in

breadth (figs. 22 to 27) and becomes somewhat shorter (figs. 24 to 26). Indentations appear in the attachment disc and at the posterior end of the oral disc; these division lines extend until the individuals separate, the last connecting bond being the velum. The two attachment discs are at first separated by a double line of short cilia (fig. 13, *u*), an ingrowth of the inner row of cilia of the original disc. Successively the other circles of cilia and the velum of each cup are completed and the individuals separate.

*Micronucleus.* (?)—This body increases in diameter from 2 $\mu$ to 3 $\mu$, becomes less stainable and therefore more difficult to follow. It moves down the neck and assumes the positions shown in figs. 21 to 23. In the stage shown in fig. 24, two such bodies were found in sections, but division has thus far eluded observation. It is to be hoped that future work on the infusorian may give the intermediate stages, and the changes in position of the two bodies in stages between those shown in figs. 24 and 27. In the specimen figured in 27 from an *in toto* preparation of fresh material stained with alum carmine, both micronuclei (?) were distinctly seen below their respective cups, and in sections of young *Licnophoræ* they are always found in normal position immediately under the attachment cup, and to the left of the axial neck fibre.

*Macronuclei.*—In the earliest stage of division seen (fig. 18), the macronuclei are distinct and unchanged in position, but very soon they begin to unite, usually in pairs, as described by Wallengren, but frequently three united and odd ones are left here and there (fig. 19). The pairs unite with one another irregularly, with a tendency to accumulate on the right side of the animal (figs. 20 and 21). The whole macronuclear substance now becomes concentrated into from one to six rounded masses located within the peristomal region (fig. 22). These masses show indications of a skein stage, but are very dense and stain deeply. The nuclear masses now lengthen out transversely in dumb-bell form and extend nearly across the broad body

of the animal (fig. 23). The ends curve upward along the line of the left hand portion of each peristomal band (figs. 24 and 25), and each mass divides into two apparently equal parts by transverse constriction (figs. 23 to 26). The nuclear masses of each half gradually take the position of the adult nuclear chain (figs. 27 to 30) and divide into segments within a common membrane, which later divides also. Gruber (1884*a*) questions as to whether the nuclei are connected by a membrane as in some other multinucleate forms. The majority of adult forms in this species and all specimens approaching division have separate nuclei, while a few fully grown individuals, probably recent products of division, show some nuclei still connected by a membrane. These conditions are plainly shown in iron-hæmatoxylin and safranin stained sections and in material stained with safranin *in toto*.

No very definite structure has been made out in dividing nuclei. In fresh material treated with formalin, acetic acid, osmic vapor, picro-acetic, or picro-carmine, a distinct longitudinal striation is visible in the nuclear masses of advanced stages (figs. 23 to 28 and 82), and a skein-like appearance in those of earlier stages (fig. 22); but other than this they appear homogeneous.

*Peristomal Band and Axial Fibre.*—The original peristome, cilia, and mouth change but little during division. The axial fibre appears unchanged both in sections and in *in toto* preparations through stage 23, but in sections corresponding to stage 24, though still attached by a branching base to the cup, the fibre is thinner aborally, and in later stages (figs. 24 to 27) it is not connected with the dividing cup.

*New Peristome.*—The first morphological indication of division, with the exception of increase in size, is the appearance on the right side of the oral disc, midway between the union of the oral disc with the neck and the posterior extremity of the body, of a small oval patch of short cilia (fig. 18, *cf.*), which in the earliest stages, seen

when about 5 $\mu$ in length, exhibited normal ciliary movements, and corresponding sections showed a distinct basal body for each cilium (fig. 15, $x$). Wallengren's pseudopodia-like stage has not been observed and must be a very early and brief condition, if it exists at all, for this species. The ciliated area enlarges until its longitudinal diameter is 30 $\mu$ to 40 $\mu$, the extension being mainly towards the attachment disc (figs. 19 and 20). The margin of the area now becomes differentiated into a peristomal spiral by the fusion of the basal bodies into transverse basal bands, and the peristomal area assumes a ventral position. The right hand end of the spire extends forward and to the left. The cilia in the center of the area remain short (fig. 12, $t$), and are gradually reduced to papilla-like points (fig. 11, $t$), while those of the band rapidly lengthen. The left hand end of the band, at first almost touching the right (figs. 11 and 16), gradually moves outward by the rapid growth of the area enclosed in the loop of the band, passes over the posterior end of the body to the dorsal side, and finally comes around to form a normal left hand spiral (figs. 21 to 27). The lengthening of the band is accompanied by separation of the transverse cilia-bearing bands, and not by multiplication of those bands by division (compare $b^2$ of fig. 11 with $b^1$ of fig. 4). The oral end of the spiral band lies flat on the surface of the animal until near the time of separation (fig. 27), when the mouth-cavity appears and the band twists under the upper lip to form the roof of the pharynx. At the time of separation, and for some time after, the two individuals can be distinguished from each other by the position and size of the mouth, and by the deeper staining qualities of the oral band of the daughter animal.

Wallengren speaks of a similar "Aufrollen" of the ciliary band, but he describes the oral end as strongly inrolled. "Aus der dexiotropen Spirale bildet sich durch Verschiebung die nach links gedrehte Peristomalzone des entwickelten Individuums dadurch aus, dass das am stärksten

eingerollte Ende der ursprünglichen Spirale sich aufrollt und nach hinten und unten geschoben wird (fig. 5 und 6, S. 29 u. 30)".

While the oral end of the spire unrolls, the other end changes the direction of its curvature from right to left (figs. 21 to 27). The various changes in position of the peristomal area and the direction of its ciliary band must be due to unequal growth without as well as within the area.

As the oral band grows and unrolls, the cytoplasm directly beneath it becomes denser and finer in structure (fig. 12, *z*), and in the stages shown in figs. 23 and 14 the basal fibre and its lateral branches have appeared, giving the usual triangular cross-section of the band. In a little later stage, the axial fibre is seen extending a short distance above the band (fig. 24), but definite connection with the attachment cup for this new axial fibre and for the original one is not effected until about the time of separation (figs. 27 and 28).

During all these changes the *Licnophora* moves actively about and feeds, at least in live cultures.

One pair were discovered when they were connected by only a narrow band of the velum, and for a half hour they whirled round and round apparently struggling to free themselves from one another. At last they separated and the one having the primary oral disc swam away, while the other whirled about in one spot for fully an hour before it became sufficiently adjusted to new conditions to swim away.

The following tabulated comparison between *Licnophora auerbachii* and *L. macfarlandi* is based on Wallengren's paper (1894), and the results which I have obtained. It shows in a concise form the salient points of difference upon which this new species is based, as well as some others which a renewed study of the European forms will doubtless show to be generic in character. Chief among the latter may be cited the axial fibre connecting the attachment disc and the oral band.

| *L. auerbachii.* | *L. macfarlandi.* |
|---|---|
| 1. Ectoparasitic. | 1. Entoparasitic. |
| 2. Detached with difficulty, disinclined to free swimming, and confused in its movements when detached. | 2. Easily detached, and swimming rapidly, with definite well coördinated movements. |
| 3. Attachment disc bordered by a single striated membrane. | 3. Attachment disk bordered by four rows of cilia forming four striated membranes. |
| 4. Ciliary membrane of attachment disc loses coördination when split up. | 4. Ciliary membranes do not so lose coördination. |
| 5. A "Haftring" with overlapping ends. | 5. No "Haftring". |
| 6. Ventral side of the attachment disc jagged ("ojemt naggad"). | 6. Ventral side of the attachment disc smooth and even. |
| 7. Long diameter of mouth-opening nearly parallel with long axis of the body. | 7. Long diameter of mouth-opening forming an angle of from 45° to 80° with the long axis of the body. |
| 8. No such structures yet described [Probably present. "Im Fuss habe ich eine Bildung beobachtet, die ich als einen kontractilen Fäden, ein Myonem gedeutet. (Taf. fig. 3, *m.*)" Wallengren]. | 8. Strong contractile axial fibre sending branches to the attachment cup, and to the oral band. |
| 9. None described. | 9. Vibratile neck membrane and its fibre. |
| 10. Stout oral membranellæ, inclined to split up into fibrils of unequal length. | 10. Long fine oral cilia of equal length, arising from transverse basal bands. |
| 11. Oral band of daughter animal formed by gradual increase in length and union of the cilia of ciliary field, from without inward. | 11. Oral band of daughter animal formed by lengthening of the outer cilia of the ciliary field, and union of their basal bodies to form basal bands, while the cilia of the center of the field degenerate. |
| 12. Oral band begins on the side of the neck. | 12. Oral band begins just above or over the extreme end of the pharynx. |
| 13. A "Peristomalrinne" present. | 13. No "Peristomalrinne" present. |
| 14. None described. | 14. A longitudinal furrow extending from the margin of the attachment disc to the mouth. |
| 15. Ciliary field before differentiation, having a band extending toward the attachment disc. | 15. Ciliary field oval, with no such band. |
| 16. Oral end of new peristomal band strongly inrolled. | 16. Oral end of new peristomal band not so inrolled. |

| | |
|---|---|
| 17. One macronuclear mass in division. | 17. From one to six such masses, each of which divides. |
| 18. None described. | 18. A very definite and constant body below the attachment disc, which is probably a micronucleus. |
| 19. Entoplasm of oral disc structureless, slimy, and somewhat granular. That of neck and attachment disc alveolar. | 19. Entoplasm of whole body distinctly alveolar and granular. |

Many details of the structure of *Licnophora* require further study, and the phenomena of conjugation are above all of the greatest interest. It is hoped that a future opportunity for work upon this organism will lead to the clearing up of these points, which for the present, however, must be offered in an incomplete form.

To the great courtesy of Privat Docent Dr. H. Wallengren of the University of Lund, Sweden, I owe especial thanks for sending me slides of *L. auerbachii* for comparison with the Monterey species.

## **Boveria**, gen. nov.

With *Licnophora macfarlandi*, in the respiratory tree of *Holothuria californica*, occurs a second ciliate infusorian of smaller size and heterotrichous structure. This form differs so widely from any previously described that I propose for its reception the new genus *Boveria* with the following characters.

Animal heterotrichous, cylindrical or tapering, with rounded ends; cilia of two sorts, (1) a general body system of fine cilia arranged in slightly curved longitudinal rows, (2) a terminal peristomal spiral of long coarse cilia in a double row, closed at both ends, and opening out at the inner end to enclose the terminal mouth. Macronucleus oval, central; micronucleus nearer aboral end. Contractile vacuole near oral end. Reproduction by oblique fission.

Genus dedicated to Dr. Theodor Boveri, Professor of Zoology in the University of Würzburg.

## **Boveria subcylindrica**, sp. nov.

PLATES IV AND V; PLATE VI, FIGS. 83 AND 84.

*General Description.*—In the living respiratory tree *Boveria* is generally seen attached to the membrane by its ciliated base and extending straight out into the lumen. In

sections it often stands with its base crowded in between folds of the inner epithelium of the membrane.

The organism is much elongated and subcylindrical in form, tapering slightly from oral to aboral end. Living specimens measure, without cilia, 54 μ to 81 μ in length, 18 μ to 21 μ in diameter at the oral end, and 9 μ to 18 μ at the aboral end ( fig. 32, also fig. 36, *a–e*).

The infusorian is very resistant to pressure and to macerating agents; osmic fixation preserves the form and size perfectly. Ordinarily its form is definite and comparatively rigid, but when in close quarters it exhibits surprising flexibility of body, doubling itself up and squeezing through the narrowest opening with the ease of amœboid forms.

The cilia are of two distinct types—long coarse peristomal cilia, and short fine body cilia. The oral cilia average one-half the length of the body, the body cilia one-eighth to one-sixth, those on the aboral end being somewhat shorter. The oral cilia are disposed in a double dexiotropic spiral of about one and one-half turns, with closed ends, the inner end widening out to enclose the mouth-opening (fig. 49). The inner peristomal cilia are somewhat shorter than the outer and more constantly active in feeding, those on opposite sides of the mouth bending toward one another, the outer very constantly and rapidly to carry food into the mouth, the inner slowly, and standing curved over the mouth, evidently to prevent food particles from escaping. The outer row alternately opens widely, rotates rapidly toward the mouth, and closes up until the tips of the cilia are interwoven, the latter phase being much longer than the former.

The general body cilia are arranged in from 20 to 27 slightly oblique longitudinal rows extending from the outer turn of the oral spire nearly to the center of the opposite end, where they leave a small circular spot free from cilia (fig. 47). These cilia are in constant rapid motion, always beating strongly toward the peristome, producing a rapid current in that direction, and at the same time driving the body rapidly backward in swimming, or holding it firmly

to its host when at rest. The animal has never been seen to swim with the oral end forward, but moves backward with a slow whirling motion in a slightly serpentine course, with slight flexions of the oral end of the body.

In other forms, where the infusorian swims with the aboral end forward, a "Mundnaht," such as is present in *Dasytricha* (Schuberg), indicates, according to Bütschli, the path of migration of the primitive mouth from the anterior to the posterior end. There is no indication of such migration in *Boveria*. The several rows of body cilia all extend in slightly converging lines from their juncture with the outer row of oral cilia to the central bare space on the aboral end. The direction of movement is therefore to be explained as a modification due to environment. The continual movement of the cilia with the strong stroke forward backs the animal up against the lining epithelium of the tube in which it lives in such a way as practically to insure it a radial position, as fixed as though it were attached to the wall; and the same kind of ciliary motion serves all ordinary purposes of food-getting and locomotion. In live cultures it is often seen attached to small masses of cells from the respiratory tree, by its basal cilia.

The mouth and pharynx are very variable in size, and the pharynx appears not to be permanent. When the animal is actively feeding, it is quite broad and deep, bending slightly to one side, but at other times it is not evident in the living infusorian, and it is rarely seen in sections (figs. 33 and 47). Various appearances of the peristomal region are shown in figs. 32, 33 and 83. In the latter appearance, which is very common when the infusorian is attached and feeding, the elevated portion is thin, concave, and nearly transparent.

A large circular contractile vacuole is located at the oral end immediately below the peristome. Its period varies from 50 seconds to 9 minutes, 35 seconds, averaging 2–3 minutes. Its relation to the peristome and form when discharging is shown in figs. 32, 48 and 49.

The nucleus is barely visible in the living animal as a clearer oval central area of relatively large size (fig. 32, $n^1$).

In the proximal half of the body are usually seen several large food vacuoles, each usually containing a single cell from the host, a leucocyte or epithelium cell. Diatomaceous food masses also occur. These vacuoles frequently pass aborally beyond the nucleus, but are most numerous in the proximal half of the body, and in the majority of cases are confined to that part.

*Structure and General Biology.*—Seen in sections (Hermann or Flemming fixation, iron-hæmatoxylin and rubin or ruthenium red), the whole body is covered with a delicate homogeneous pellicula, beneath which, and always adhering closely to it, is a dense, finely granular layer of ectoplasm, in which are imbedded the oval, deeply-staining basal bodies of both systems of cilia. These basal bodies are clearly visible in life as strongly refringent points beneath the pellicula (figs. 47, 48, 50, 51, $b^1$, $b^2$). No myonemes can be distinguished, and no definite longitudinal contraction has been observed other than that necessary to produce slight flexions of the body when attached.

The entoplasm is distinctly alveolar, coarsely about the nucleus and finely at both ends. Near the aboral end is a much denser band, having the form of a concavo-convex lens, with the concave side toward the nucleus. The position and form of this dense area, visible in the living animal as well as in sections (fig. 48), suggest that it may have something to do with the animal's adherence to its host, but further observations are necessary to establish such a function.

*Macronucleus.*—Centrally placed is a large oval macronucleus with a definite membrane and coarsely granular contents. The granules, stained by iron-hæmatoxylin, are scattered over the inner surface of the nuclear membrane, and are gathered in a more or less centralized mass, in which a linin thread-work forms a basis for the granules

and extends to the peripheral ones on the membrane (figs. 48 and 50, $n^1$). This centralization of the nuclear contents would seem to be a shrinkage product of fixation, if specimens like those shown in fig. 35 had not been repeatedly seen lying side by side in material fixed on the slide with osmic vapor, picro-carmine, etc. There seems to be a stage immediately preceding and following division, when the chromatin is more evenly distributed through the nucleus, the whole presenting a more homogeneous appearance, while the intervening periods are characterized by the arrangement described above.

*Nucleoli.*—In many sections, a non-staining material is seen in rounded or lenticular masses at the ends of the chromatin aggregation, more rarely at the sides (figs. 53–55, *e*). This substance has a pale yellowish gray color in sections from material fixed in picro-acetic, Hermann's or Flemming's fluids. These masses have rarely been seen in sections of division stages, and then not occupying any significant position, such as is assumed by the "Polplatten" in *Spirochona*, *Paramœcium*, etc. Possibly they are comparable to Hertwig's plastin nucleoli in *Actinosphærium*.

*Micronucleus.*—Near the aboral end of the organism is a small, very definite and constant micronucleus (diameter 1.5 $\mu$), staining readily with iron-hæmatoxylin, methyl-green, picro-carmine, etc. (fig. 48, $n^2$). Around it in sections is a narrow clear space, bounded by the semblance of a membrane, scarcely more than the alveolar walls in resting stages, but more definite in early division stages, and disappearing in the final stages of division. This more or less definite limiting boundary of the peri-micronuclear space seems to be not a homogeneous secretion, but to be due to greater or less compression of the surrounding alveoli. It is, however, very constant.

*Division Phenomena.*—The phenomena of nuclear division were first observed in fresh material treated on the slide with picro-carmine,—this reagent simultaneously fixing and

staining the animals most excellently,—and mounted temporarily in glycerine. Certain unusually large forms showed a shortened condition of the oral cilia, oblique position of the nucleus, and two micronuclei near the macronucleus (fig. 37). In the next stage the macronucleus was decidedly elongated, and contained a suggestion of an equatorial plate; the two micronuclei were located at or near the poles of the macronucleus, and indentations already indicated the line of division of the cell body (fig. 39). In all the cases observed, the second micronucleus passed forward along the aboral side of the obliquely placed macronucleus to its oral pole. In later stages the central portion of the cell elongates and is differentiated unsymmetrically to form a new peristomal portion for one animal and a new aboral portion for the other (figs. 40–45). Meanwhile the macronucleus divides with indications of a primitive variety of karyokinesis. In a few cases something like an equatorial plate has been observed in both *in toto* preparations and in sections, and later stages show two distinct plates with a fibrillar appearance between them. The chromatin, during division, appears in the form of coarse granules rather than as distinctly individualized chromosomes.

Separation of the nuclear mass is complete for some time before the membrane divides, it being drawn out in the form of a narrow tube or a thin thread between the two daughter nuclei (figs. 43 and 44). Finally, the vestiges of the connecting thread disappear, the two nuclei round up, and the narrow bond holding the two individuals together breaks; the result is two daughter animals alike in every respect (fig. 46), with the exception of the position of the micronucleus. The point of separation of the two cells gives the non-ciliated aboral spot, described above, in one individual, while in the other no trace remains. The young *Boveria* is short and broad compared with adult specimens, and the nucleus is rounded or elongated transversely (fig. 46).

During the early stages of division, the original peristome becomes inconspicuous, its cilia nearly as short as those of the body system, and the mouth and pharynx disappear,

parallel differentiation of a new peristomal spiral and mouth taking place in the two individuals during the later stages. The exact details of this process have thus far eluded observation.

A contractile vacuole appears in each individual in the stage shown in fig. 42, *v*.

One individual with two buds was observed alive, but unfortunately escaped from the preparation in the process of fixation (fig. 84).

In only two cases was division of the micronucleus seen in fresh material (fig. 34, $n^2$, methyl-green acetic). The two micronuclei appeared as equally and evenly stained spheres connected by two colorless membrane-like lines in optical section. Careful searching through hundreds of sections gave the very striking series shown in fig. 67, *a–j*, indicating a variety of mitotic division, but too incomplete for satisfactory interpretation. The first indication of approaching division of the infusorian is an enlarged and coarsely granular appearance of the micronucleus (*b*); this continues to increase in size, and the chromatin assumes the form of two crescent-shaped bands held in place by a delicate fibre attached to each band and to the surrounding membrane (*e*); division of the chromatin bands within the membrane is indicated in *g*, while in the stage shown in *h* the membrane has disappeared and we have three (?) chromatin bands at each end of a spindle, each two daughter bands being connected by a single fibre. The bands now unite to form compact oval masses still connected (*i*); the two new micronuclei round up, the spindle fibres disappear, and a membrane is formed around each (*j*).

Figures 56, 57 and 59 show the relation of *e*, *h* and *i* to the macronucleus. Figures 58, 60*b*, 62 and 63 were from material fixed with Boveri's picro-acetic, which gives a somewhat different appearance to the nuclear contents, the chromatin granules showing a tendency to arrangement in longitudinal rows during the various stages of nuclear division.

Figures 61–66 show sections of stages corresponding to those shown in figures 39–44, in which may be compared the changes in the chromatin granules as far as made out. The minute structure of the macronucleus of *Boveria* is a difficult object of study, especially in these stages of division, and many points remain unsettled, which it is hoped that further studies and experimentation with fixing fluids of varied composition and strength may clear up. Chief among these is the detail of the division and distribution of the chromatin granules so clearly seen in figs. 41–43.

Comparison of the figures just cited shows that while subject to considerable variation there is a decided tendency in the micronuclei to take positions at the poles of the macronucleus during division. Division of the micronucleus and polar migration of its halves invariably precede division of the macronucleus. No specialized morphological connection, however, has been made out between micronucleus and macronucleus at any stage; so that for the present, at least, their reciprocal positions must be regarded as merely coincident phases of the same general physiological process of division, though one is strongly tempted to consider the bearing which these phenomena may have upon the phylogeny of the centrosome.

Though division in *Boveria*, when observed superficially, appears to be a process of budding, careful examination of the details shows that we have here, not ordinary budding as in *Spirochona*, where the daughter animal is wholly a new growth and separates from the parent in an immature state, but what may be styled oblique fission. It will be observed from comparison of figs. 37–46 that one individual,—the right-hand one in fig. 44,—receives the peristomal half of the parent animal, its aboral portion being newly formed, while the other individual has a newly differentiated peristomal region joined to the aboral half of the parent animal. Figure 39 shows well the division of the original animal between the two daughter animals.

## SUMMARY OF CHARACTERISTICS.

1. Backward swimming, with no indication of a "Mundnaht".

2. Peristomal spire consisting of two rows of cilia united at the ends and including the terminal mouth within the inner end of the spire.

3. Apparent atrophy of the mouth and peristomal spire as a prophase of division, and differentiation of the same for each daughter animal as a telophase.

4. Peculiar disposition of the chromatin granules at rest and in division, and non-staining homogeneous nucleolar masses of unknown function.

5. Constant aboral position of the micronucleus at a distance from the macronucleus in resting stages.

6. Apparent mitotic division of the micronucleus as the initiative of cell division.

7. Polar position of the micronucleus during macronuclear division.

8. Division by lateral or oblique fission.

Conjugation has not yet been observed in either *Licnophora macfarlandi* or *Boveria subcylindrica*.

## RELATION OF THESE INFUSORIA TO THEIR HOST AND TO EACH OTHER.

Ordinarily there is no apparent relation between the two forms. So far as can be seen through the wall of the living respiratory tree, both are usually attached to the membrane, feeding busily and quite independently. Similar food masses are found in each,—diatoms and leucocyte-like or epithelium cells. In several holothurians, however, where the number of both forms was very great, many of the *Licnophoræ* had been feeding upon the *Boveriæ*. In serial sections from this material, several cases were found in which, as in fig. 10, an individual of *Boveria subcylindrica* is held within the pharynx of a *Licnophora*, and others in which a *Boveria* occurs as a rounded food mass

posterior to the mouth region of a *Licnophora*. In a crowded preparation, one *Licnophora* was seen to reach repeatedly with a part of the cilia on the left side of the oral disc, aided by flexion of the neck and oral disc, for one of the *Boveriæ*, finally seize it and carry it toward the mouth, where it was quickly drawn down into the pharynx, and later passed on into the body like any other mass of food.

Almost nothing definite can as yet be stated as to the relation of these infusoria to their host. There is no evidence to show that they are injurious parasites. So far, no difference has been observed between the condition of the respiratory membrane in individuals containing few or no infusoria, and that in those containing large numbers.

The structure and some of the movements of *Licnophora* have suggested that it might be able to loosen epithelial cells from its host for food, but such regeneration of the epithelium as would naturally follow has not been observed.

The most probable supposition, at present, is that the infusoria have found here a safe haven where they are constantly supplied with fresh sea-water containing an abundance of food in the form of diatoms, minute protozoa, etc., supplemented by waste material from the host.

Where these infusoria come from, and how they pass from the parent to the young holothurian is at present a mystery; for they are found only in the respiratory organ, and no trace of them has been discovered on the surface of this holothurian, on or within other holothurians, or on nudibranchs or worms similar to those on which the other species of *Licnophora* live as ectoparasites. Surface towing at various times has also failed to reveal them as free swimming forms. A more detailed examination of the habitat of *Holothuria californica* may, however, clear up these points.

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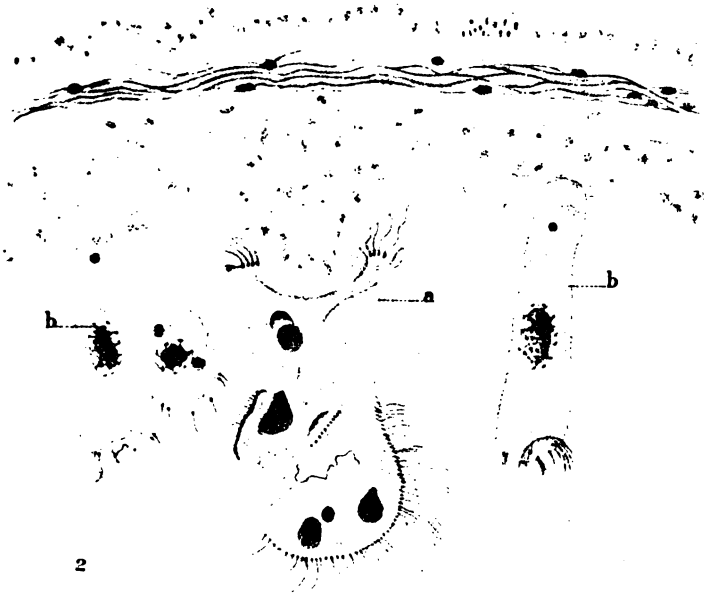
## EXPLANATION OF PLATE I.

*Licnophora macfarlandi*, sp. nov.

Fig. 1. Section of respiratory tree of *Holothuria californica* with both infusoria attached to the lining epithelium. *a*, *Licnophora macfarlandi; b*, *Boveria subcylindrica*. Fixed with Hermann's fluid, stained with Heidenhain's iron-hæmatoxylin. Leitz, ocular 3, objective 7, camera lucida.

Fig. 2. Dorsal view of living *Licnophora* attached to glass slide. *a*, attachment disc; *b*, neck; *c*, oral disc; $m^1$, outer ciliary membrane; *v*, velum underneath ciliary membranes; *d*, end of smaller neck fibre; *e*, vibrating neck membrane; *p*, pharynx; *f*, food mass; *g*, oral cilia. L. oc. 3, ob. 7, cam.

Fig. 3. Ventral view of *Licnophora* attached to cover-glass. Lettering same as in fig. 2. *h*, ventral neck groove; $m_1$, $m_2$, $m_3$, $m_4$, ciliary membranes; *i*, transverse basal band of oral ciliary band; *o*, mouth-opening. L. oc. 3, ob. 7, cam.

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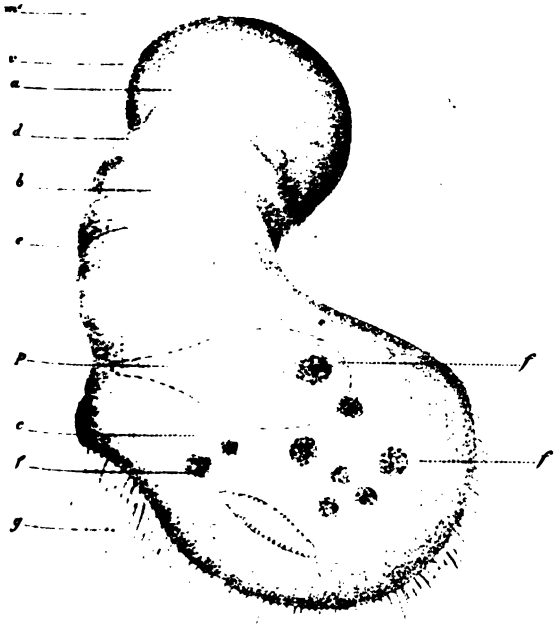


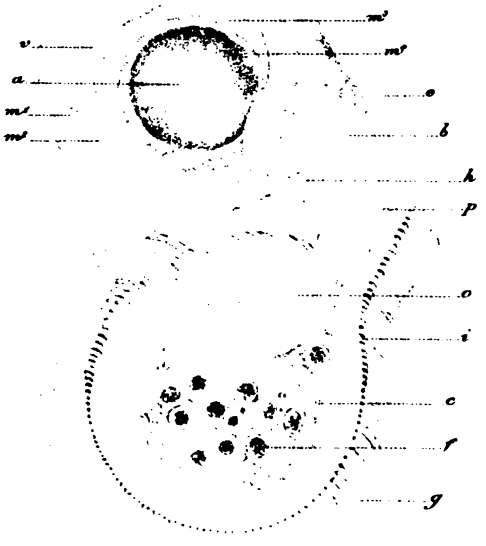


W.M. STEVENS, DEL. LITH. BRITTON & REY. I

LICNOPHORA MACFARLANDI, SP. NOV.

## EXPLANATION OF PLATE II.

### *Licnophora macfarlandi*, sp. nov.

Fig. 4. Oblique longitudinal section, cut through centre of attachment disc, and just dorsal to the roof of the pharynx. Lettering in general same as in Plate I. *j*, pellicula of attachment cup; *k*, ectoplasmic layer; *l*, fibre layer; $n_1$, one of the macronuclei; $n_2$, micronucleus; $f_1$, larger neck fibre; $f_2$, smaller neck fibre; $s_1$, cross-section of oral band; $b^1$, basal band of cilia, Hermann fixation, iron-hæmatoxylin staining. (Same fixation and staining for figs. 4 to 16.) L. oc. 3, ob. $\frac{1}{12}$, cam.

Fig. 5. Oblique section through attachment cup, showing velum (*v*), bases of cilia (*b*), fibre layer (*l*), branching base of neck fibre ($f_1$), and a portion of the smaller neck fibre ($f_2$). L. oc. 3, ob. $\frac{1}{12}$, cam.

Fig. 6. Slightly oblique section through base of the ciliary membrane, showing four rows of basal bodies. L. oc. 3, ob. $\frac{1}{12}$, cam.

Fig. 7. Oblique section through attachment disc just below the fibre layer of the cup, showing micronucleus ($n_2$), larger neck fibre ($f_1$), ventral neck groove (*h*), and vibratile neck membrane (*e*). Zeiss, oc. 3, ob. D, cam.

Fig. 8. Oblique section of attachment disc, showing concentric wave-like appearance of ciliary membranes (*m*) and vibratile neck membrane (*e*). L. oc. 3, ob. 7, cam.

Fig. 9. Transverse section through oral disc, showing the cilia-bearing bands of the roof of the pharynx, with basal fibre above. L. oc. 3, ob. 7, cam.

Fig. 10. Oblique transverse section through oral disc, showing *Boveria subcylindrica* gen. et sp. nov. in the mouth and pharynx of *Licnophora*. L. oc. 3, ob. 7, cam.

Fig. 11. Superficial longitudinal section of left side of dividing *Licnophora*, showing newly formed oral band—right spiral—with central cilia degenerating (*l*). Z. oc. 6, ob. D, cam.

Fig. 12. Transverse section through new oral band (fig. 11 at level of *a–b*); a slightly earlier stage than that shown in fig. 11, showing transverse cilia-bearing band (*z*), no basal fibre, short cilia through the central portion of the field, and long fine ones on the ciliary bands. L. oc. 3, ob. $\frac{1}{12}$, cam.

Fig. 13. Oblique longitudinal section through a specimen in an advanced stage of division, showing the inner short cilia on the dividing line between the two cups (*u*). L. oc. 3, ob. 7, cam.

Fig. 14. Longitudinal section of a division stage later than those shown in figs. 11 and 12, showing cross-sections of new oral band with basal fibre ($s_2$), micronucleus enlarged and changed in position ($n_2$), and concentrated nuclear mass ($n_1$). L. oc. 3, ob. 7, cam.

Fig. 15. Tangential section showing a portion of ciliary field with short cilia and distinct basal bodies (*x*), also united macronuclei ($n_1$). L. oc. 3, ob. $\frac{1}{12}$, cam.

Fig. 16. Tangential section of dividing individual, showing right-coiled secondary oral band ($b_2$), and a part of the primary band ($b_1$), at an earlier stage than fig. 11. L. oc. 3, ob. $\frac{1}{12}$, cam.

Fig. 17. Reconstruction from several camera drawings of specimens macerated with potassium bichromate, showing the relation of the larger neck fibre to the attachment cup and to the transverse cilia-bearing bands of the oral band ($b_1$); *y*, the larger divisions of the neck fibre in the fibre layer of the attachment cup. Cilia shown diagrammatically at but two places.

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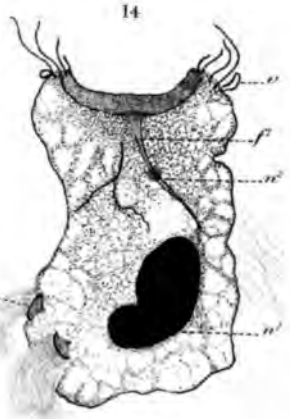

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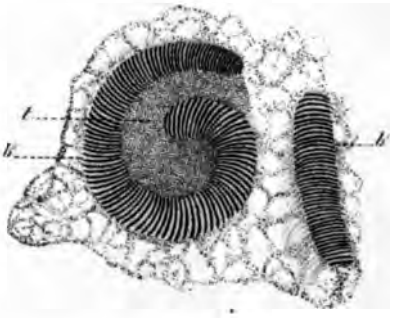

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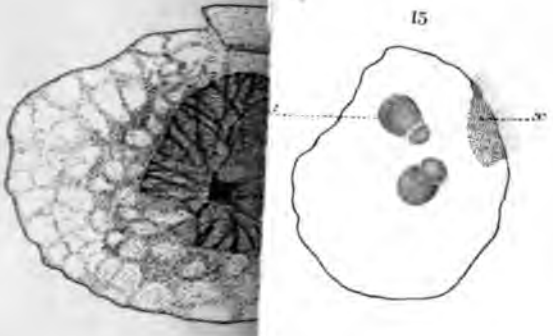

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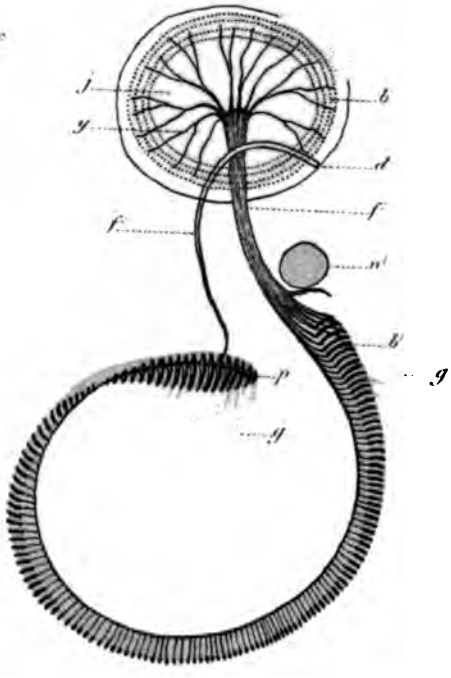

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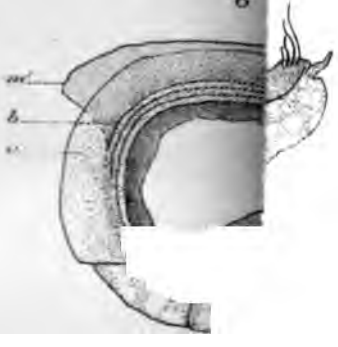

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## EXPLANATION OF PLATE III.

*Licnophora macfarlandi*, sp. nov.

Figs. 18–31. Successive division stages from glycerine preparations of material killed with formalin or osmic vapor and stained with alum carmine. Detail of cilia not represented. Zeiss, oc. 3, ob. D, cam. (Figures reduced to two-thirds their original size.)

Fig. 18. Ciliary field (*cf*) very small, macronuclei not yet united.

Fig. 19. Ciliary field larger, macronuclei ($n_1$) uniting.

Fig. 20. Ciliary field still larger, macronuclei united into irregular masses.

Fig. 21. Ciliary field differentiated into a right spiral band ($b_2$), macronuclei united into two bands, micronucleus enlarged and a short distance below the attachment cup, attachment disc increasing in transverse diameter.

Fig. 22. Secondary peristomal band elongating and unrolling, macronuclei united into rounded masses; micronucleus on the border between neck and oral disc.

Fig. 23. Secondary peristomal band still elongating and unrolling; macronuclear masses elongated transversely—dumb-bell shape; micronucleus just above the primary mouth.

Fig. 24. Secondary peristomal band beginning to turn toward the left; macronuclear masses approaching division; micronucleus divided, one near the oral end of each peristomal band ($n_2$) (Division not observed.); attachment disc beginning to divide; a distinct notch between the two oral discs.

Fig. 25. Secondary peristomal band turned toward the left, oral end on the dorsal side; macronucleus nearly divided, ends lying along the ciliary bands; attachment cup nearly divided.

Fig. 26. Secondary band distinctly læotropic; nuclear bands extending toward the attachment disc; the two attachment cups separated by ingrowth of the inner row of cilia.

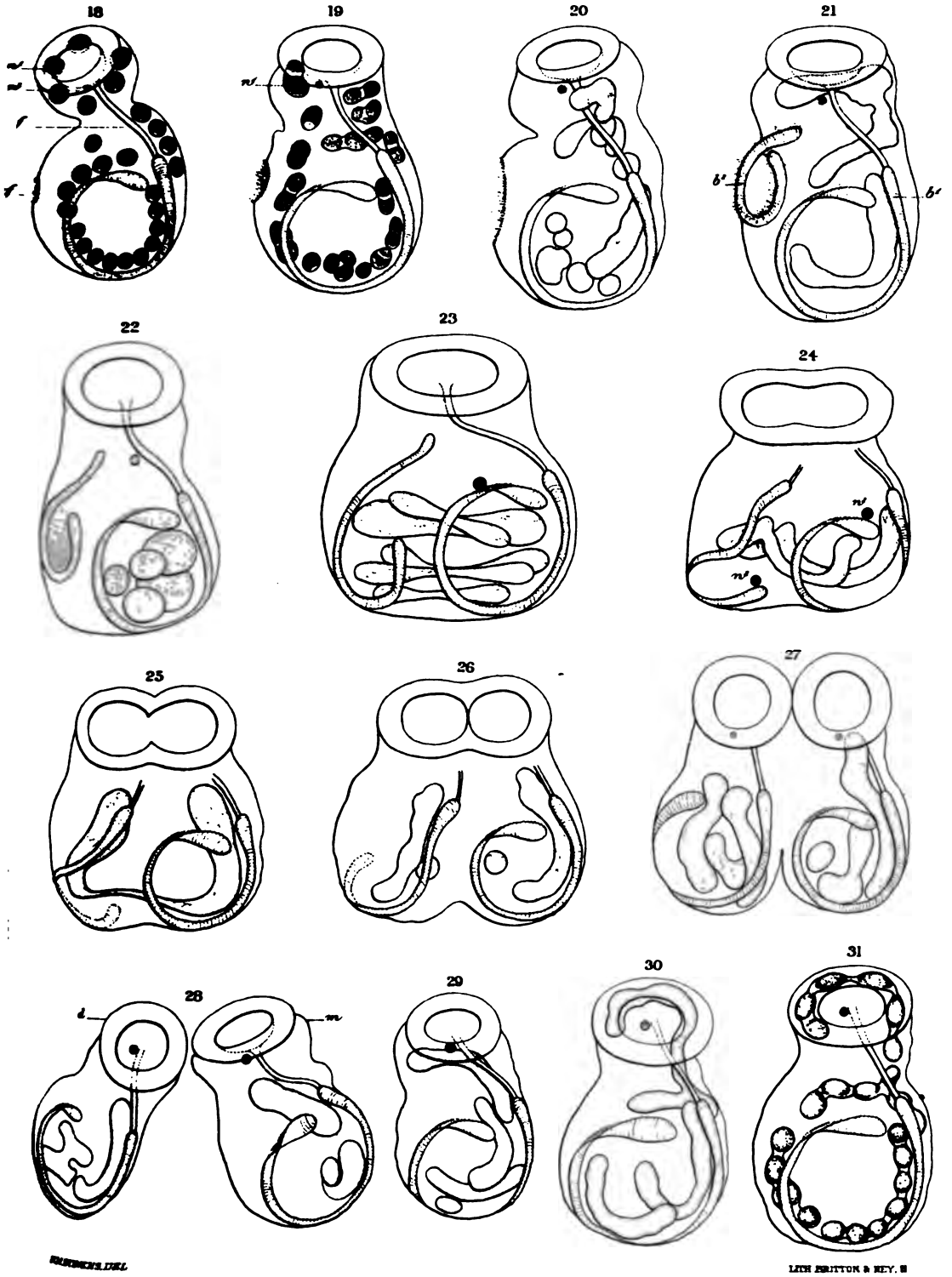
Fig. 27. Oral end of secondary peristomal band appears on the ventral surface of the daughter *Licnophora*, but is not yet twisted into a mouth-opening; micronuclei in each attachment disc near the adult position; two attachment cups fully developed; division indentation between the two oral discs advancing.

Fig. 28. Two *Licnophoræ* just separated, oral band of daughter animal (*d*) showing the twist at the end, but the mouth and pharynx not yet fully formed; micronuclei in usual position.

Fig. 29. Young individual, perfect in every respect but still small and with macronuclear bands not yet segmented.

Fig. 30. Young individual of adult size, nuclear bands taking the position of the segments of the resting stage.

Fig. 31. Young individual showing segmentation of the nuclear band.




LIONOPHORA MACFARLANDI, SP NOV

## EXPLANATION OF PLATE IV.

*Boveria subcylindrica*, gen. et sp. nov.

Fig. 32. View of living *Boveria subcylindrica; m*, mouth; *c*, cilia of peristome; *v*, contractile vacuole; *f*, food mass; $n_1$, macronucleus. Z. oc. 3, ob. E, cam.

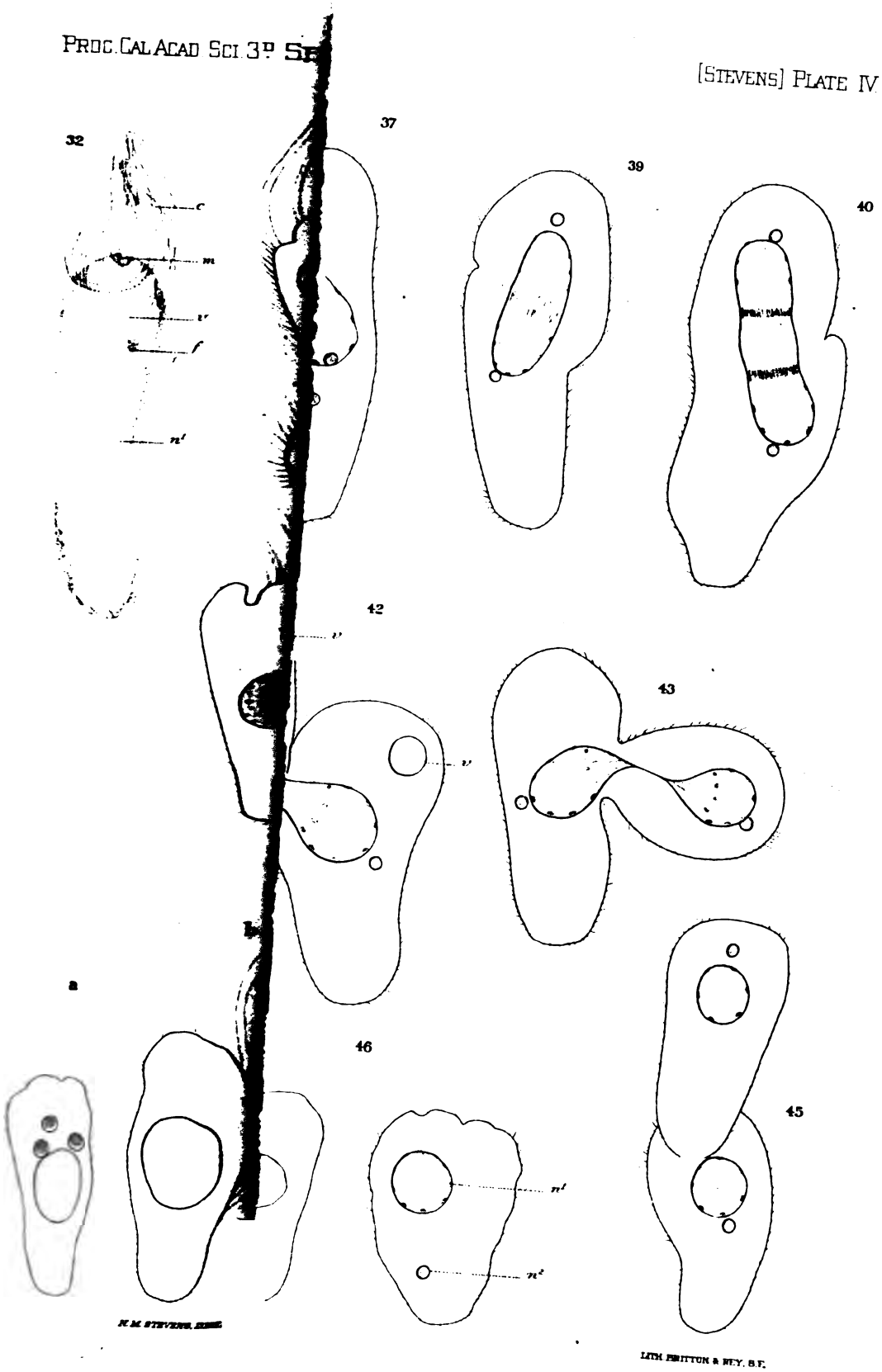
Fig. 33. Freehand sketch of a specimen attached and feeding; *p*, pharynx.

Fig. 34. Two individuals showing dividing micronuclei ($n_2$). Methyl-green-acetic on fresh material. Z. oc. 8, ob. D, cam.

Fig. 35. Two individuals showing different conditions of the macronucleus ($n_1$), found side by side in a preparation of fresh material fixed with 1 per cent. formalin and stained with picro-carmine. Z. oc. 8, ob. D, cam.

Fig. 36, *a–e*. A series of specimens fixed with osmic vapor, showing variations in size and form. L. oc. 3, ob. 7, cam.

Figs. 37–46. Division stages arranged in series, from fresh material fixed on the slide with 1 per cent. formalin and stained with picro-carmine. Z. oc. 8, ob. D, cam.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## EXPLANATION OF PLATE V.

*Boveria subcylindrica*, gen. et sp. nov.

Figs. 47–56, 60*a*, 61, 64, 66: Hermann's fluid, iron-hæmatoxylin. Figs. 57, 58, 60*b*, 62, 63: Boveri's picro-acetic, iron-hæmatoxylin.

Fig. 47. Superficial longitudinal section showing longitudinal rows of body cilia with basal bodies ($b_2$), peristomal cilia with basal bodies ($b_1$), mouth ($m$), and pharynx ($p$). Z. oc. 4, ob. 1.5, cam.

Fig. 48. Median longitudinal section showing mouth ($m$), contractile vacuole ($v$), food mass ($f$), macronucleus ($n_1$), micronucleus ($n_2$), dense ectoplasm and alveolar entoplasm. Z. oc. 4, ob. 1.5, cam.

Fig. 49. Peristomal spire, from a superficial transverse section of the peristome, showing only the basal bodies of the peristomal cilia, and the contractile vacuole ($v$) discharging. Z. oc. 8, ob. 1.5, cam.

Fig. 50. Median transverse section through the macronucleus ($n_1$).

Fig. 51. Transverse section through micronucleus ($n_2$). Z. oc. 4, ob. 1.5, cam.

Fig. 52. Superficial transverse section of aboral end of the animal, showing converging rows of body cilia, basal bodies ($b_2$) only being shown. Z. oc. 8, ob. 1.5, cam.

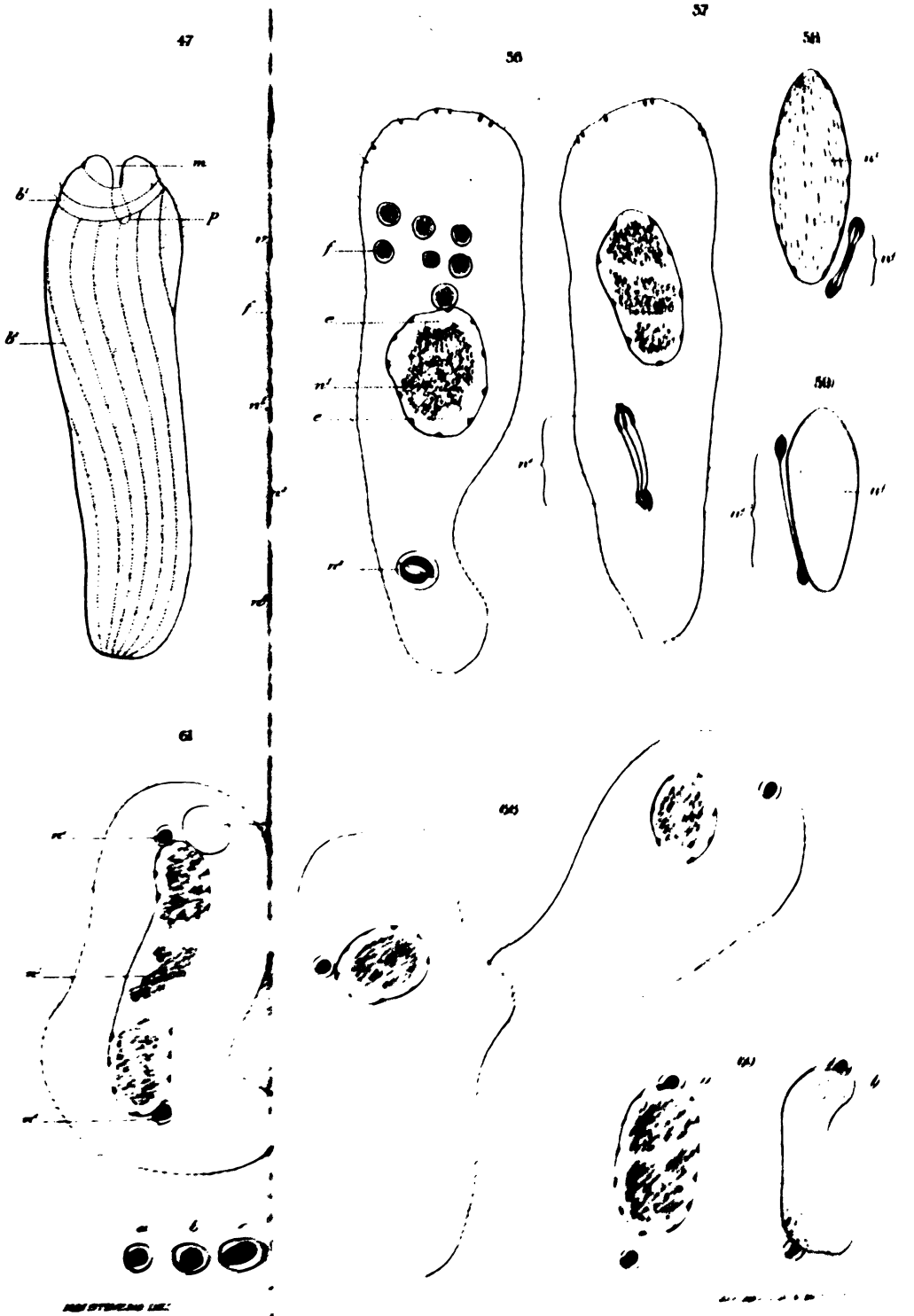
Figs. 53–55. Macronucleus showing nucleoli ($e$) varying in form and position. Z. oc. 4 and 8, ob. 1.5, cam.

Figs. 56 and 57. Section showing stages in division of the micronucleus ($n_2$). Z. oc. 4, ob. 1.5, cam.

Figs. 58–60. Nucleus in early stages of division, showing micronucleus in division ($n_2$). Z. oc. 4, ob. 1.5, cam.

Figs. 61–66. Sections showing advanced division stages corresponding to those shown in figs. 40–45, Plate IV. Z. oc. 4, ob. 1.5, cam.

Fig. 67, *a–j*. Sections showing division stages of micronuclei arranged in incomplete series.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56
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58A
58B
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## EXPLANATION OF PLATE VI.

Figs. 68–82. *Licnophora macfarlandi*, sp. nov.
Figs. 83, 84. *Boveria subcylindrica*, gen. et. sp. nov.

Fig. 68. Freehand sketch of living *Licnophora*, showing a characteristic appearance when attached.

Fig. 69. Diagrammatic outline of *Licnophora*, showing proportions of a large living specimen. $a-b=180\mu$, $c-d=72\mu$, $e-f=54\mu$, $g-h=30\mu$, $i-j=70\mu$, $k-l=25\mu$, $o=30\mu$, $m=30\mu$; *v*, velum, *cm*, ciliary membranes.

Fig. 70. Diagram showing direction of rotation of *Licnophora* when attached.

Fig. 71. *a*, basal band with brush of fine cilia; *b*, same, with cilia twisted; *c*, one end of basal band, with cilia twisted.

Fig. 72. Diagram showing the relative proportions of the transverse cilia-bearing bands at the beginning of the oral band.

Fig. 73. Cross-sections of oral band: *a*, at the beginning of the spire; *b*, an average section; *c*, in the pharynx.

Fig. 74. Diagram showing relation of neck fibre to the transverse cilia-bearing bands.

Fig. 75. Attachment disc in outline, showing position and relation of the two neck fibres and the larger branches of $f^1$, in the fibre layer of the cup. Potassium bichromate maceration. Z. oc. 8, ob. 1.5, cam.

Fig. 76. Freehand sketch of living attachment disc of *Licnophora*, cut off just below the attachment of the neck fibre, showing large neck fibre ($f^1$), small neck fibre ($f^2$), neck membrane (*e*) still vibrating when drawn, two parts of the velum ($v^1$, $v^2$), outer ciliary membrane ($m^1$), and micronucleus ($n^2$); *p* is the cut edge of the neck.

Fig. 77. Camera sketches showing three phases of the vibration of the neck membrane. *a*, expansion of membrane; *b*, greatest elevation of the point of the fibre (*d*), accompanied by greatest tenseness of the membrane (*e*); *c*, phase just preceding disappearance of the membrane.

Fig. 78. Three nuclear segments within the common membrane.

Fig. 79. Nuclei stained with iron-hæmatoxylin, showing large granules.

Fig. 80. Nuclei stained with safranin.

Fig. 81. Nuclei stained with picro-carmine, showing deeper staining threads, granules and vacuoles.

Fig. 82. Macronucleus in division stage, showing longitudinal striation. Z. oc. 8, ob. 1.5, cam.

Fig. 83. Diagrammatic sketch, showing appearance of peristome in feeding.

Fig. 84. Sketch of living individual with two buds.

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# Coccidæ (Scale Insects) of Japan

BY

SHINKAI INOKICHI KUWANA

WITH SEVEN PLATES

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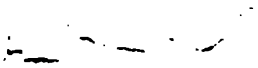

# COCCIDÆ (SCALE INSECTS) OF JAPAN.

BY SHINKAI INOKICHI KUWANA,

*Assistant in Entomology, Leland Stanford Jr. University.*

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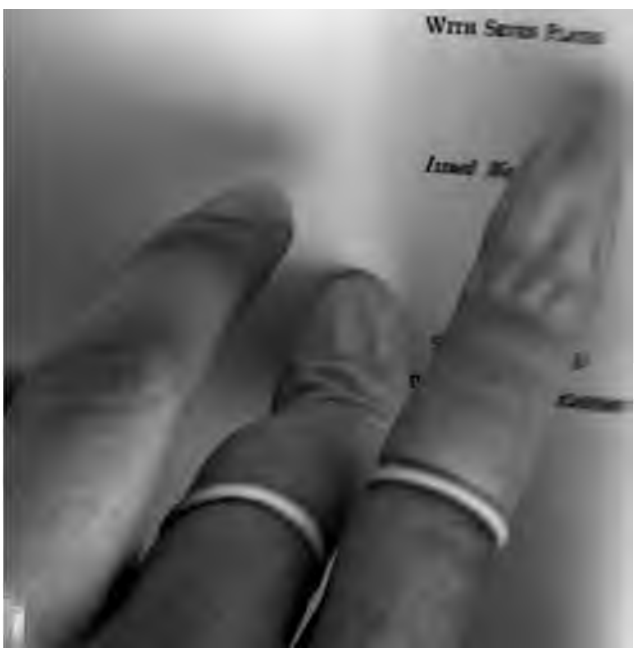
ZOOLOGY

# Coccidæ (Scale Insects) of Japan

BY

SHINKAI INOKICHI KUWANA



This paper was prepared in the Entomological Laboratory of Stanford University, under the direction of Professor V. L. Kellogg.

## II. DESCRIPTIONS OF NEW SPECIES AND IDENTIFICATION OF OLD SPECIES.

## Family COCCIDÆ.

### Subfamily MONOPHLEBINÆ.

### Genus **Monophlebus** *Leach.*

#### 1. **Monophlebus burmeisteri** (?) *Westwood.*

*Monophlebus burmeisteri* WESTWOOD, Arcana Entom., 1841, 1, 22, 4. SIGNORET, Essai, 1875, p. 364. MASKELL, Trans. & Proc. New Zealand Inst., Vol. XXIX, 1896, p. 327.

Four specimens of this species were found by the author in Hikosan, Kiushiu. The name of the host is unknown. Previous to this A. Koebele had found it on *Pinus* sp., in Yokohama.

#### 2. **Monophlebus corpulentus,** sp. nov.

PLATE VII, FIGS. 1-3.

*Adult Female.*—Color brownish, legs and antennæ black, thinly covered with a white cottony secretion which is thicker on the ventral aspect. Elliptical in form, thick, segments distinct. Size of the largest specimen 16 mm. long, 7 mm. wide. When examined with compound microscope the skin shows a dense pubescence of short and long hairs, and many round pits. Antennæ nine-segmented, 1.6 mm. long; formula, 9, 5, (1, 2, 4, 6, 3) (7, 8); each segment bearing several rather long hairs. The measurements of the antennal segments are as follows:—

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| *Length*.. | 133 | 166 | 183 | 166 | 200 | 166 | 150 | 150 | 200 |
| *Width*... | 466 | 250 | 200 | 200 | 200 | 166 | 133 | 133 | 150 |

Rostral loop long; mentum conical, dimerous. Legs subequal, stout; anterior pair smaller than posterior pairs; coxa wider than long; trochanter triangular in shape; femur very thick, outer margin convex, shorter than

tibia; tibia more than twice as long as tarsus; inner margin of tibia and tarsus bearing several strong spiny hairs; all segments with many hairs; claw large, with one to four spine-like digitules on its inner margin. Anal ring hairless.

Found by the author on the trunk of *Quercus* sp. in the grounds of Nishigahara Agricultural Experiment Station, Tokyo.

This species is related to *Monophlebus burmeisteri* Westwood, but may be readily distinguished from the latter by its great size, legs much thicker and stouter, femur comparatively short.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus **Icerya** *Sign.*

### 3. **Icerya** sp.

Two specimens were obtained by the author in Mr. Yafune's orange orchard, Arita-gun, Yakayamaken. Not being in a good condition the species could not be determined.

Subfamily MARGARODINÆ.

## Tribe *Xylococcini.*

### **Sasakia**, gen. nov.

Adult female with nine-segmented antennæ; body distinctly segmented, mouth-parts wanting in the adult stage; no digitule on claw nor on tarsus; anal tube absent; enclosed in a cottony secretion.

Larva with six-segmented antennæ; anal tube wanting.

### 4. **Sasakia quercus**, sp. nov.

PLATE VII, FIGS. 4-8.

*Adult Female.*—The adult female is usually found in crevices on bark, in a white cottony secretion. Color red; antennæ and legs reddish brown. Length 1.85 mm., width about 1 mm.; subelliptical, narrower toward anterior. Antennæ close to each other, very stout, nine-segmented, constricted at base of each segment, about .5 mm. long; formula, 1, 9, (2, 3, 4, 5, 6, 7, 8); segment 1 very stout and long; segments 2 to 8 subequal; short hairs on each segment. Legs subequal, very stout; coxa stout, as wide as long.

trochanter large; femur very stout, outer margin very convex; tibia as long or longer than femur, with at least six knobbed hairs, and many spines at the posterior end; tarsus less than half as long as tibia; outer margin convex, inner margin concave, and bearing four or more spiny hairs; claw very stout and curved; no digitules on claw nor on tarsus; anal tube wanting. There are small round pits on the dorsum.

*Intermediate Stage.*—Length .6 mm.; width .7 mm.; suboval, slightly narrower toward anterior; color red. Antennæ and legs wanting; mouth-parts prominent; rostral loop long.

*Newly Hatched Larva.*—Length about .2 to .25 mm.; elliptical in outline, narrower toward anterior end. Color red; antennæ and legs pale. Eyes round and prominent. Antennæ very large, club-shaped, and close together; six-segmented; formula 6, 1, 3, 4, 5, 2; segment 6 very much the longest, as long as all the others together; segment 1 next to the longest and very broad; segment 2 shortest; each bearing a few hairs. Mouth-parts very large; rostral loop long. Legs subequal; coxa wider than long; femur stout; tarsus short; digitules fine hairs; claw, long and slender. Posterior end of the body with two long hairs and a few very fine scattered hairs. Margin of body with capitate hairs. Anal tube wanting.

This species was found by the author on *Quercus myrsinæfolia* (Shira-gashi) and *Quercus acuta* (Katagi), in Tokyo, and on *Quercus acuta* in Chikujo-gun, Kiushiu.

"The absence of the anal tube in younger stages allies it with certain species of *Cœlostoma*" (Pergande).

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

Subfamily COCCINÆ.

Tribe *Asterolecanium.*

Genus **Lecaniodiaspis** *Targ.*

### 5. Lecaniodiaspis quercus *Ckll.*

*Lecaniodiaspis quercus* COCKERELL, Psyche, Supp., 1896, p. 19; Bull. T. S. No. 4, Div. Ent., U. S. Dept. Agric., 1896, p. 51.

This species was found by the author on *Quercus acuta* (Katagi), *Pasarnia glabra* (Matera-shii), and *Q. sessilifolia* (Tsukubane-gashi) in Tokyo, and *Q. acuta* in Chikujo-gun, Kiushiu. It was originally described by Cockerell from specimens sent to the Division of Entomology, U. S. Department of Agriculture, by O. Takahashi, Tokyo.

## Tribe *Kermesini.*

### Genus **Kermes** *Boitard.*

### 6. **Kermes nakagawæ**, sp. nov.

PLATE VI[illegible]

*Adult Female.*—Length 4 to 5 mm., width 5 to 6 mm., height 3.5 to 4 mm. Color dark brown with black transverse markings; covered with waxy, grayish white secretion. A broad median longitudinal groove; in the groove near the base is a round protrusion which usually has a grayish white flake on each side. Antennæ very small, about .1 mm. long, three-segmented; formula 3, 2, 1; segment 3 much the longest, longer than 1 and 2 combined; last segment bearing four or five long hairs. Legs vestigial, only three parts being apparent; claw large, curved; one pair of digitules.

*Newly Hatched Larva.*—Length 4 mm., width .2 mm.; oval in shape. Color pinkish; antennæ and legs pale brown. Mouth-parts large, well-formed; rostral loop long. Antennæ short, only .1 mm. long, six-segmented; formula, 6 (3, 2, 1) (5, 4); segment 6 longest; 4 shortest; segment 1 stoutest. Legs short and stout; tibia and tarsus about equal in length; tarsal digitules fine and knobbed, digitules on claw short and stout; claw large, curved, and denticulate on its inner side. Margin of body with capitate hairs; two rows of capitate hairs on thoracic and abdominal segments. Ventral aspect with five rows of fine hairs. Caudal lobes terminated with a long hair; three spines behind the anal opening.

This species was found by the author on the trunk of *Quercus serrata* (Kunugi) in Akabane, *Quercus* sp. in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo, and on *Q. glandulifera* (Nara) at Hikosan, Kiushiu. The scales are usually found in groups, and are badly infested by parasitic hymenoptera.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

### 7. **Kermes nawæ**, sp. nov.

PLATE VIII, FIGS. 16–22.

*Adult Female.*—Length about 6.5 mm,, width 7 mm., height nearly 5 mm., globose in outline. Color shining chestnut brown; dorsum with five black transverse markings; no longitudinal groove; thinly covered with white powder. When taken off, the specimens leave some of the white cottony substance on the tree. Antennæ and legs very small. Antennæ consist of five segments, .16 mm. long; formula, 3, 4, 5, 2, 1; segment 3 the longest; terminal segment bearing several rather long hairs; the others a few short ones. Mouth-parts well developed; mentum very large, conical,

dimerous. Legs subequal; coxa stout, not very much shorter than femur; trochanter small, triangular, with two spines; tarsus longer than tibia; tarsal digitules fine and knobbed, digitules on claw short and stout; claw large, with a minute denticle on its inner margin.

*Newly Hatched Larva.*—Length .6 mm., width .3 mm.; elliptical in form; color pale brown. Antennæ and legs very large, well developed. Antennæ six-segmented; segment 6 [redacted] segments 1 to 5 with a few hairs; segment 6 bearing many rather long hairs; formulæ:—

6, 1, 3, 2, (4, 5).
6, 3, (2, 1) 4, 5.
6, (1, 3) (2, 4, 5).
6, 3, 1, (2, 4, 5).
6, (3, 1) (4, 5) 2.

Mouth-parts very large; rostral loop longer than body; mentum large and conical. Margin of body with conspicuous, spiny hairs. Two capitate hairs on submargin close to first spiracle. Legs subequal; tibia about one-half as long as tarsus; four fine hair-like digitules; claw slender, denticle on its inner margin. Ventral aspect of body with transverse rows of fine hairs; posterior end of body furnished with lobes, each terminated by a long hair, and three spines, two on inner side of the hair and one on the outside. Anal ring hairless.

This species was found by Mr. Nawa on *Quercus glandulifera* (Nara) in Fukui-ken, and by Mr. A. Onuki, on *Rhamnus japonica* var. *genuina* (Kuro-umemodoki) in Nagano-ken.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Tribe *Eriococcini.*

## Genus **Eriococcus** *Targ.*

### 8. Eriococcus graminis (?) *Mask.*

*Eriococcus graminis* (?) MASKELL, Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 243.

This species was found on bamboo, in Gifu-ken. The original description was made by Maskell from specimens sent to him by A. Koebele, who had found them on grass in Hongkong.

### 9. Eriococcus japonicus, sp. nov.

PLATE VIII, FIGS. 23–25.

*Adult Female.*—Female sac, length about 1.7 mm., width about 1 mm.; convex, elliptical; color pale straw.

Female, length about .65 mm., width, .4 mm.; oval in outline, anterior end narrow, segments distinct. Antennæ five-segmented, about .1 mm. long; formula, 5, 3, 1, 2, 4; segment 5 longest; 4 shortest; segment 6 with many hairs; the others with few. Anterior pair of legs smaller than posterior pairs; coxa large; trochanter very small, bearing a long hair; femur stout, convex on both sides; tarsus longer than tibia; claw large, curved; digitules on tarsus long and fine, digitules on claw short and short. Coxa of second and third pairs of legs very large, almost as long as femur. Margin of body with spines; each abdominal segment with a transverse row of strong spines; spines on thorax not in a row. Posterior end of body furnished with two lobes, each bearing a long hair and a few spines. Anal ring prominent, and bears six hairs.

*Eggs.*—Length .4 mm., width .25 mm.; elliptical; brown in color.

*Male Cocoon.*—Length .7 mm., width .3 mm.; elliptical; same color as the female sac.

This species was found by the author on *Symplocos myrtacea* (Hainoki) in Chikujo-gun, Kiushiu.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 10. Eriococcus onukii, sp. nov.

PLATE VIII, FIGS. 26–28; PLATE IX, FIGS. 29–33.

*Adult Female.*—Female sac, length about 3.5 mm., width 2 mm.; strongly convex, suboval in outline, usually with five transverse ridges on the dorsum, but sometimes only four. Color of the sac white inclining to grayish.

Female reddish brown. When boiled in KOH turns red; spread out under cover-glass measures 2.5 to 3 mm. in diameter; dorsum with strong spines, ventral aspect bearing many fine scattered hairs. Mouth-parts well formed, rostral loop short. Antennæ seven-segmented, .23 mm. long; segment 1 stout and shortest; segment 3 longest, but not much longer than 4; terminal segment with several long hairs, the others with a few short ones; formulæ:—

3, 4, 7, 2 (5, 6) 1
(3, 4) 1, 7, 2, 6, 5 } one specimen.

(3, 4, 7) 2 (5, 6) 1
(3, 4) 7, 2 (5, 6) 1 } one specimen.

(2, 3, 7) (4, 5) 6, 1
3, 7, 2, 4 (5, 6) 1 } one specimen.

Legs as usual, subequal; coxa large, stout, longer than wide, bearing a few spines; trochanter rather large, subtriangular, with two long and one short spiny hair; tibia shorter than tarsus, with two spines on inner margin of posterior extremity; tarsus slightly tapering toward end; tarsal digitules long, knobbed, and hair-like, digitules on claw short, slightly extending beyond

claw; claw large, well curved, with denticle on its inner margin. The posterior end of the body is furnished with lobes, each terminated by a long hair and a spine. Anal ring very prominent, with eight hairs.

*Egg.*—Length .3 mm., width .17 mm.; oval in shape; color pale brown.

*Newly Hatched Larva.*—Length .41 mm., width .2 mm.; long, elliptical in form, very much like that of *Gossyparia ulmi*. Antennæ six-segmented, .1 mm. long; formula, 3, 6, 2 (1, 4, 5), segment 3 longest; segment 1 stoutest; segment 6 with many long hairs; the others with a few. Mouth-parts large; rostral loop reaching to the fourth abdominal segment. Legs subequal, large; tibia very much stouter than tarsus; tarsal digitules fine and knobbed, digitules on claw short, extending only slightly beyond claw. Margin of body with very strong spines; dorsal aspect of thoracic, and first two abdominal segments, with two spines. Abdomen tapering toward posterior extremity, and furnished with lobes, each bearing long hairs and two spines. Anal ring with six hairs.

This species was found by the author on *Arundinaria hindsii* var. *graminæ* (Kanzanchiku) in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus **Gossyparia.**

### 11. **Gossyparia ulmi** *Geoff.*

*Gossyparia ulmi* GEOFF. SIGNORET, Essai, 1875, p. 21. HOWARD, Insect Life, Vol. II, 1890, p. 34. COCKERELL, Proc. Phil. Acad., 1899, p. 268. *Gossyparia spuria* MODEER.

This species was found by K. Oyama, on *Ulmus* sp., in Nagano-ken. It differs, however, from the specimens found on Stanford University campus in having the body of the adult female entirely covered by the waxy secretion. Microscopic characters show no difference.

## Tribe *Dactylopiini.*

## Genus **Dactylopius** *Costa.*

### 12. **Dactylopius comstocki,** sp. nov.

PLATE IX, FIGS. 34 AND 35.

*Adult Female.*—Length 4 mm., width 2 mm.; long oval in outline, slightly narrow in front. Dark purple in color; antennæ and legs brown; body dusted with white powder.

When boiled in KOH the color is purple. Antennæ eight-segmented, .5 mm. long; segment 8 longest; 3 next in length, but not much longer than 2; segment 8 bearing many hairs; the others a few; formulæ:—

8, 3, 1, 2, 5, 6, 7, 4.
8 (3, 2) 1, 7, 5, 6, 4.
8, 2 (3, 1) [illegible] 6.
8 (2, 3) 1, 5, [illegible] 7.
8 (2, 3, 1) 5, 6, 4, 7.
8 (2, 1) 3, 5, 4 (6, 7).

The measurements of the antennal segments vary as follows:—

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 47 | 53 | 50 | 27 | 33 | 36 | 36 | 94 |
| 2 | 41 | 53 | 47 | 22 | 25 | 27 | 33 | 91 |
| 3 | 44 | 66 | 55 | 36 | 41 | 41 | 44 | 108 |
| 4 | 44 | 55 | 53 | 39 | 39 | 39 | 44 | 111 |
| *Ave.* | 44 | 56 | 51 | 31 | 34 | 34 | 39 | 101 |

Mouth-parts large; rostral loop long. Spiracles large. Legs normal; coxa longer than wide, with several spines; trochanter as usual, bearing one long and a few short hairs; femur thick, outer margin convex, with many scattered hairs; tibia as long as femur, tapering posteriorly, with many hairs; tarsus about one-third as long as tibia, tapering posteriorly, with many hairs; tarsal digitules fine and knobbed, digitules on claw short, gradually widening into large knobs. Dorsum with fine scattered hairs and round pits. Posterior end of body furnished with lobes, each bearing a fine long hair and two stout spines. Anal ring round, prominent, with six hairs.

Found at Akabane by the author in cracks or crevices of trunk of mulberry-tree (Kuwa), near the ground, and protected by a covering made by ants. The ants and scales associate in the chamber, being mutually benefited. It was also found in the crevices of the trunk of a kind of maple in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo.

This species is related to *Dactylopius theobromæ* Dougl. The two species may be separated by the following table:—

| *Dactylopius comstocki.* | *Dactylopius theobromæ.* |
|---|---|
| Segment 8 of antenna very much shorter than 5, 6, and 7 together. | Segment 8 of antenna equal to 5, 6, and 7 together. |
| Tarsi one-third length of tibiæ; claw rather long and large. | Tarsi half the length of tibiæ; claw short. |

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 13. Dactylopius pini, sp. nov.

PLATE IX, FIGS. 36–38.

*Adult Female.*—Found among growing needles of pine. A white cottony secretion covers all the body. Color, reddish brown; legs and antennæ brown. When boiled in KOH the color turns purple. Length about 4 mm., width about half the length. Margin of body with fine simple hairs; dorsum with fine hairs and minute round pits. Antennæ eight-segmented, .4 to .5 mm. long, hairy; segment 8 always longest; 4 usually shortest; segments 2 and 3 subequal. The following formulæ show the variations in the relative lengths of the antennal segments:—

8, 2, 3, 1 (6, 7) 5, 4.
8, 2, 3, 1, 7, 6, 5, 4.
8, 2, 3 (1, 7) (5, 6) 4.
8, 2, 3 (1, 7) (4, 5, 6).

The measurements of the antennal segments vary as follows:—

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| 1 | 83 | 75 | 88 | 47 | 55 | 53 | 50 | 111 |
| 2 | 80 | 83 | 83 | 47 | 55 | 47 | 53 | 108 |
| 3 | 72 | 77 | 72 | 53 | 58 | 44 | 47 | 111 |
| 4 | 77 | 80 | 80 | 53 | 64 | 50 | 47 | 116 |
| 5 | 75 | 75 | 75 | 47 | 55 | 50 | 41 | 105 |
| 6 | 77 | 77 | 72 | 53 | 64 | 44 | 44 | 111 |
| *Ave.* | 77 | 77 | 78 | 50 | 58 | 45 | 47 | 110 |

Mouth-parts as usual; rostral loop long. Legs round; coxa short, wider than long; trochanter triangular, with one long and two or more short hairs; femur large, outer margin convex; tibia not so stout as femur, but almost equal to it in length; tarsus less than half the length of tibia; segments with many

projecting hairs; tarsal digitules long, fine, knobbed, and hair-like; digitules on claw quite stout and short, extending a little beyond claw; claw thick, curved. Anal ring round, prominent, with six hairs. Caudal hairs short, with two strong spines.

*Newly Hatched Larva.*—Larva taken from the female is oval in shape; length about .35 mm., half as wide as long. Antennæ five-segmented, about ⅓ mm. long; formula, 5, 3, 2, 1, 4; segment 5 longest; 4 shortest; terminal segment with many prominent hairs; others with comparatively few. Margin of body with fine simple hairs. Legs large and subequal. Posterior end of body furnished with prominent lobes, each bearing a long hair with two stout spines at the base. Anal ring distinct, with six hairs.

Found by the author on *Pinus* sp. in Koishiwara, Kiushiu, and on *Pinus pentaphylla* (Goyo-matsu) in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo.

This new species is closely allied to *Dactylopius sequoiæ* Coleman, but they may be separated by the following table:—

| *Dactylopius pini.* | *Dactylopius sequoiæ.* |
|---|---|
| Female enclosed in a sac. | Female not enclosed in a sac. |
| Female with no egg-sac on the caudal ventral aspect. | Female with egg-sac on the caudal ventral aspect. |
| Female gives birth to young. | Female lays eggs. |
| Antennæ of young five-segmented. | Antennæ of young six-segmented. |

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 14. Dactylopius kraunhiæ, sp. nov.

PLATE IX, FIGS. 39 AND 40.

*Adult Female.*—Enclosed in a cottony sac, of irregular shape; color reddish brown. When boiled in KOH and spread out under cover-glass measures about 2 mm. in length and 1.5 mm. in width; broad elliptical in form. A transverse row of spines on the dorsal aspect of each segment; ventral aspect with fine hairs; dorsum covered with small round pits. Antennæ and legs large, brown in color. Antennæ eight-segmented, .5 mm. long, hairy; formula, 8, 3, 2, 1, 5 (4, 6, 7); the measurements of each antennal segment, (1) 69–69; (2) 77–80; (3) 83; (4) 55; (5) 56; (6) 53; (7) 55; (8) 111; segment 6 slightly longer than 3; segment 3 slightly longer than 2; segments 4, 5, 6 and 7 subequal; segment 1 stoutest. Mouth-parts comparatively large; rostral loop long, extending down to the first or second abdominal segment. Legs subequal, hairy; coxa much wider than long; trochanter as usual, bearing a few spiny hairs; femur thick, outer margin convex; tibia slightly shorter than

femur and three times as long as tarsus; tarsal digitules fine and knobbed, digitules on claw stout, short, and knobbed; claw as usual, curved. Each of the marginal lobes of the posterior segment bears a single long hair, with two spines at the base. Anal ring large, prominent, with six hairs.

This species was found by the author on *Kraunhia floribunda* (Fuji) at the Yok[redacted]a Nursery, Yokohama.

This is allied to *D. pini* Kuwana, but the body of the former is shorter and more stout, the legs and antennæ larger in proportion to the body, and segment 8 of the antenna is as long or not quite so long as 6 and 7 together, while 6 is not much longer than 3.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus **Phenacoccus** *Ckll.*

### 15. Phenacoccus pergandei (?) *Ckll.*

*Phenacoccus pergandei* COCKERELL, Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 55.

This species was found by the author on *Diospyros kaki* (Kaki) in Kusatsu, Shiga-ken. The specimens are in a poor condition.

## Genus **Sphærococcus** *Mask.*

### 16. Sphærococcus parvus *Mask.*

PLATE IX, FIG. 41.

*Sphærococcus parvus* MASKELL, Ent. Mon. Mag., Vol. XXX, 1897, p. 244; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 247.

This species was found by the author on the trunk of a cherry-tree in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo. Previous to this it had been found for the first time by A. Koebele, on a cherry-tree in Japan (the locality not mentioned), and described by Maskell as a new species.

Mr. Maskell evidently made a mistake when he considered the antennæ of the newly hatched larvæ to be composed of six confused segments. They are distinctly

three-segmented[1], about .23 mm. long; formula, 3, 1, 2. Anal ring of larva with six hairs. Antennæ of female appear to be two-segmented. Maskell's statement in regard to the anal ring being without bristles is erroneous. There are six small bristles or hairs.

## Genus **Antonina** *Sign.*

### 17. Antonina crawi *Ckll.*

*Antonina crawi* COCKERELL, Psyche, Vol. IX, 1900, p. 71.

*Newly Hatched Larva.*—Length .4 mm., width .2 mm.; oval in shape; purple in color. Antennæ six-segmented, about .14 mm. long; formula, 6 (5, 4, 2) (1, 3); segment 6 much the longest; 2, 4 and 5 subequal; 3 shortest; segment 6 with many long hairs. Three pairs of legs subequal; tibia shorter than tarsus; claw slender and rather long; four digitules, lower pairs very stout. The dorsum covered with small round pits. Caudal end of abdomen bears two long hairs. Anal ring prominent, with six hairs.

This species was found by the author at the sheathing bases of leaves of different kinds of bamboo, in different places in Japan: on *Phyllostachys nigra* (Kuro-chiku), *Phyllostachys quilioi* (Madake), and on *Arundinaria simoni* (Narihira-dake) in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo, on Madake in Akabane, and on many kinds of bamboo in Kiushiu. Sometime before this it had been found on bamboo from Japan by A. Craw, in quarantine work at San Francisco.

## Genus **Pseudolecanium** *Ckll.*

### 18. Pseudolecanium tokionis *Ckll.*

*Pseudolecanium tokionis* COCKERELL, Psyche, Supp., 1896, p. 16; Bull., No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 49; Psyche, Vol. IX, 1900, p. 71. KUWANA, Proc. Cal. Acad. Sci., 3d Ser., (Zool.) Vol. II, 1901, p. 403.

This species was found by the author on bamboo in the vicinity of Tokyo, and on the same host in Gifu-ken. It

[1] Mr. Pergande, who examined the author's specimen, says the antennæ consist of four segments.

was originally described by Cockerell from dry specimens sent to the Division of Entomology, U. S. Department of Agriculture, by O. Takahashi, Tokyo. In 1899 the author found it on bamboo on the Stanford University campus, and the male in different stages was described by him.

Subfamily LECANIINÆ.

SERIES I.

## Genus **Pulvinaria** *Targ.*

### 19. Pulvinaria psidii *Mask.*

PLATE X, FIG. 42.

*Pulvinaria psidii* MASKELL, Ent. Mo. Mag., Vol. XXXIII, 1897, p. 243; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 242.

This species was found by the author on *Diospyros kaki*, in Gifu-ken, on Tsuta in Hikosan, Kiushiu. A. Koebele had also found it on *Citrus*, *Pittosporum* and *Eurya japonica*, in Japan.

### 20. Pulvinaria aurantii *Ckll.*

PLATE X, FIG. 43.

*Pulvinaria aurantii* COCKERELL, Psyche, Supp., 1896, p. 19; Bull., No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 48.

*Newly Hatched Larva.*—Length .4 mm., width .21 mm.; suboval; abdominal cleft distinct. Rostral loop long. Antennæ and legs large, well developed. Antennæ six-segmented; formula, (6, 3) 1, 2, 4, 5. Three pairs of legs subequal; tibia and tarsus about equal in length. Margin of body with fine simple hairs. Anal plates conspicuous, each with a very long hair.

This species is one of the worst pests in the orange orchards. It occurs in almost every part of the Empire. The author collected it in the following places: on orange in Kokura, Chikujo-gun, Kato-mura, and Hukuoka City, in Kiushiu, and in Wakayama-ken, Kiyoto, Osaka, Gifu-ken, Aichi-ken, Tokyo, and Yokohama, in Hondo. It was also found on *Eurya ochnacea* (Sakaki), in Chikujo-gun, Kiushiu, and on tea-plant in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo.

## 21. Pulvinaria horii, sp. nov.

PLATE X, FIGS. 44–52.

*Adult Female.*—Found usually in crevices of bark or in any sheltered place on trunk and large limbs, singly and in clusters. Color pale brown. The scale is circular, with many short lines radiating from the margin toward the center; in the center two longitudinal lines are bordered by two transverse lines, forming a quadrangle with a much raised longitudinal median line. The scale is not covered with secretion. Ovisac snow white, its base ranging from 4 to 5 mm.; ovisac extending posteriorly and laterally, with many distinct, radiating grooves, as shown in the figure; the posterior end of scale distinctly cleft. When boiled in KOH and spread out under a cover-glass measures about 8 mm.; circular in outline; abdominal cleft deep. Antennæ eight-segmented, .41 mm. long; formula 2 (3, 4, 5) 6, 7, 8, 1; segment 2 longest; 3, 4, and 5 subequal and next in length; segment 1 stoutest and shortest; segment 8 with many long hairs; the others with few. Mouth-parts small; rostral loop short. Margin of body with fine simple hairs; each anterior incision has a long spine with a short one on each side. Legs subequal; coxa longer than wide, with two or more spines; trochanter the usual shape but small, with one long and a few short hairs; femur, the longest segment of the leg, is as wide as coxa and bears a few spines; tibia slender, almost as long as femur; tarsus less than half the length of tibia, with four digitules and a terminal claw; tarsal digitules fine and knobbed, digitules on claw stout and knobbed; claw large and curved. Triangular plates small but conspicuous, several spiny hairs along posterior portions. Anal ring large, bearing many (eight ?) long hairs.

*Newly Hatched Larva.*—Length .66 mm., width .4 mm.; broadly elliptical, front rounded, widest in thoracic regions. Color reddish brown; legs and antennæ pale brown. Eyes red and distinct. Margin of body with fine simple hairs, rather far apart; in each anterior incision is a long spine with a short one on each side. Mouth-parts large; rostral loop extending to about the third abdominal segment. Antennæ and legs large. Antennæ usually seven-segmented, .2 mm. long, hairy. The proportional lengths of antennal segments are variable even in the same specimen, but segment 3 is always the longest. The following formulæ show the variations:—

3, 7 (2, 6) 5, 4, 1.
3, 7, 2, 4, 5, 6, 1.
3, 6, 4, 5, 2, 1.
3, 6 (4, 5) 2, 1.
3, 4, 7, 5, 2, 6, 1.
3 (4, 5) 6, 2, 1.
3, 8, 2, 5 (4, 6, 7) 1.

Three pairs of legs subequal, anterior pair slightly smaller than the posterior pairs; coxa quite large, longer than wide, with a few hairs; trochanter small and triangular, with one long and a few short hairs; femur the largest segment of leg, and as wide as coxa; tibia shorter than femur, with a few spiny hairs along outer margin; tarsus much shorter than tibia, tapering posteriorly, and

furnished with spiny hairs on outer margin; four digitules and a large curved claw at posterior extremity; tarsal digitules fine and knobbed. Caudal end of the body deeply cleft; triangular plates very large, with a long hair and a few fine spines at their posterior margins. Anal ring prominent, with six long hairs.

This species was found by the author on the trunks of *Acer trifidum* (To-kæde), *Æsculus turbinata* (Tochino-ki), and *Kœlreuteria paniculata* (Mokugenji), in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo; it is named in honor of S. Hori, Entomologist of the Station.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 22. Pulvinaria oyamæ, sp. nov.

PLATE XI, FIGS. 53–56.

*Adult Female.*—A cottony mass suboval in form, there being at the narrower end a dark brown scale sometimes flattened, and sometimes bent upward at about its middle to nearly a right angle; oval, slightly broader behind, where it is notched and apparently cleft for a short distance in the middle. Dorsum with five or six transverse wrinkles or folds, and many raised lines running outwardly on each side to the posterior margin. Length of sac 6 mm., width about 4 to 5 mm., snow white, no distinct groove; scale dark brown.

When boiled in KOH and spread out under cover-glass, measures about 5 to 7 mm. in length and 4 to 5 mm. in width. Mouth-parts well chitinized but small; rostral loop short. Antennæ usually 8-segmented, terminal segment bearing many long hairs, the others a few; relative lengths of antennal segments are variable, but segment 3 is longest, as may be seen in the following formulæ:—

3, 5, 2, 4, 1 (6, 7, 8).
(3, 2, 4) 5, 6, 8, 7, 1.
(3, 4) 2, 5 (6, 7, 8) 1.

Legs subequal; coxa stout, longer than wide, with a few long spiny hairs; trochanter as usual, with one long hair; femur stout, with a few scattered hairs; tibia shorter and smaller than femur, with several long hairs on the inner margin and weak hairs on the outer margin; tarsus one-half as long as tibia, with spiny hairs; tarsal digitules long, fine, and knobbed, digitules of claw very stout, gradually widening to large knobs; claw large and curved. Margin of body with spiny hairs, in each anterior incision is one large spine with a short one on each side. Anal plates as usual, posterior extremity rounded, with a few long hairs. Anal ring with eight prominent hairs.

This species was collected by K. Oyama, in Nagano-ken. The host is unknown.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

### 23. Pulvinaria hazeæ, sp. nov.

PLATE XI, FIGS. 57-59.

*Adult Female.*—Length with ovisac about 37 mm., width 5 mm.; ovisac white, without groove (the scales having been long exposed to weather the ovisacs were in so poor a condition that the texture could not be determined); scale, diameter 4.5 mm.; subcircular in outline; light brown in color.

When boiled in KOH and spread out under cover-glass, diameter about 6 mm. Antennæ eight-segmented, about .56 mm. long; formula, 3, 4, 2, 5, 8 (6, 7) 1; segment 3 much the longest; segment 1 stoutest and wider than long; the last segment bearing many long hairs. Mouth-parts small but well formed; rostral loop short. Anterior pair of legs smaller than the posterior pairs; coxa stout, longer than wide; trochanter the usual triangular shape, with one long spiny hair; femur large and as broad as coxa; tibia shorter than femur, with many long hairs; tarsus about one-third as long as tibia, with several spiny hairs; tarsal digitules long and knobbed, digitules of claw stout, gradually widening to large knobs; claw stout and curved. Margin of body with fine simple hairs; in each anterior incision is one large spine, with a short one on each side. Anal plates distinct, yellowish brown, with three or more rather long spiny hairs near posterior margins. Anal ring with six hairs.

*Egg.*—Length .3 mm., width .2 mm.; oval in shape; color brown.

This species was found by the author on the trunk of *Rhus succedanæ* (Haze-no-ki) in Koishiwara, Chikujo-gun, Kiushiu.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus Takahashia *Ckll.*

### 24. Takahashia japonica *Ckll.*

*Takahashia japonica* COCKERELL, Psyche, Supp., 1896, p. 20; Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 47.

*Egg.*—Length .5 mm., width .3 mm.; elliptical in form; color pinkish brown.

*Newly Hatched Larva.*—Length .8 mm., width .35 mm.; elliptical in form; color brown; abdominal cleft distinct; margin of body with spiny hairs; anterior marginal incision with three subequal spines. Mouth-parts large; rostral loop reaching to about the third abdominal segment. Antennæ six-segmented; formula (6, 3, 5) (1, 2, 3). Legs rather large. Anal plates large, each bearing a long hair.

This species was found by the author on the mulberry-tree in Hukuoka, Gifu, Tokyo, and Sendai, and on other plants in Gifu and Saitama-ken.

SERIES II.

## Genus Ericerus *Guer.*

### 25. Ericerus pela *West.*

*Ericerus pela* WEST, C. R. tome X, pp. 618-666; Revue Zoologique de Guerin-Meneville, 1830, p. 120; Gardeners' Chronicle, London, 1853, p. 532. SIGNORET, Essai, 1874, pp. 91, 92. SASAKI, Zool. Mag., Tokyo, Japan, No. 114, pp. 111-116. (In Japanese.)

This interesting insect has been known in certain parts of the Empire for years as producing wax. It is known to the people by the name of Ibota-mushi, because of its feeding on *Ligustrum ibota* or Ibota-no-ki. According to C. Sasaki, it has been recorded from Hukushima, Tottori, Nagano and Kochi-ken.

The author's specimens (male) were obtained from Y. Nawa, Gifu.

## Genus Ceroplastes *Gray.*

### 26. Ceroplastes floridensis *Comstock.*

*Ceroplastes floridensis* COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 331.

This species was found by the author on oleander, in Wakayama-ken, and on the tea-plant in Tokyo and Yokohama. This is the first time it has been recorded from Japan.

### 27. Ceroplastes ceriferus *And.*

*Ceroplastes ceriferus* AND. MASKELL, Trans. & Proc. New Zealand Inst., Vol. XXV, 1892, p. 216. CRAW, Rept. Calif. State Bd. Hort., 1895-96, p. 44.

This species was found by the author on *Taonobo japonica*, (Mokkoku), in Minoshima, Wakayama-ken, and on the tea-plant in Kokura, Kiushiu. It is one of the worst tea-plant pests. In a plantation near Kokura the trees were

badly infested by this pest. Mr. Alexander Craw, San Francisco, found this insect on camellia, gardenia, and orange-trees from Japan.

SERIES III.

## Genus **Lecanium** *Illig.*

### 28. Lecanium (Saissetia) hemisphæricum *Targ.*

*Lecanium hemisphæricum* TARG. COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 334.

This species was found by the author on *Phajus grandiflorus* (Kwaku-ran) and *Gardenia florida* (Kuchinashi) in the grounds of the Yokohama Nursery, Yokohama, and on *Schinus molle* and *Asparagus plumosus* in a green-house in Shinjiku, Tokyo. The insect was not found in the native woods. This is the first time it has been recorded from Japan.

### 29. Lecanium (Eulecanium) takachihoi, sp. nov.

PLATE XI, FIGS. 60–64.

*Adult Female.*—Length 6.5 mm., width 4 mm., height 4 mm., convex; dark brown in color; suboval, longitudinal carina distinct, anterior half of the scale much enlarged, gradually tapering posteriorly. Abdominal cleft distinct. The dorsum with irregular pits.

Under the compound microscope the skin shows hexagonal markings, and round, scattered, transparent pits. Antennæ seven-segmented, .5 mm. long; formula, 3, 4, 7, 6, 5, 2, 1; segment 3 not much longer than 4; segments 5 and 6 subequal; segment 1 shortest and stoutest; segments 1 to 6 with a few hairs; 7 with many long ones. Legs well developed; coxa longer than wide; trochanter as usual, with two hairs; femur convex on both sides, with two hairs on outer margin near posterior extremity; tibia a little longer than tarsus, with two hairs on inner margin near posterior extremity and one hair on the outer margin opposite the two; tarsus tapering posteriorly, and finished with a curved claw; tarsal digitules long and knobbed, digitules on claw short and stout. Anal plates rather small, with one or two spiny hairs at the posterior margin.

*Newly Hatched Larva.*—Length .58 mm., width .27 mm.; oval in shape; pinkish in color. Antennæ six-segmented, barely .2 mm. long; formula, 3, 6, 5, 1 (2, 4); segment 3 much the longest; segment 6 with many long hairs. Mouthparts large; rostral loop reaching to about the third abdominal segment. Legs large; coxa stout and long; tarsus much shorter than tibia; tarsal digitules long, fine, and knobbed; digitules on claw short, small, and knobbed. One long and a few short hairs on the posterior end of each anal plate. Anal opening conspicuous, with six hairs.

This species was found by the author on a chestnut-tree, in Hikosan, Kiushiu, and is named in honor of N. Takachiho.

This scale is allied to *Lecanium pruinosum*, but is not covered with white powder.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

### 30. Lecanium rotundum (?) *Réaumur.*

*Lecanium rotundum* (?) RÉAUMUR. SIGNORET, Essai, 1873, p. 428.

Two specimens were found by the author on the prune-tree, in Shinjiku, Tokyo.

### 31. Lecanium (Calymnalus) hesperidum *L.*

*Lecanium (Calymnalus) hesperidum* L. COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 335.

This species is a common green-house pest in Japan. The author found it on *Abutilon* sp., *Nerium odorum* (Kyochikuto), *Jasminum* sp., *Cycas revoluta* (Sotetsu), and *Eriobotrya japonica* (Biwa), in the green-house of the Agricultural College, Sapporo, Hokkaido, and on *Cercis chinensis* (Hana-zuo), in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo. The scales are commonly infested by parasitic hymenoptera. This is the first time it has been recorded from Japan.

### 32. Lecanium (Saissetia) oleæ *Bernard.*

*Lecanium (Saissetia) oleæ* BERNARD. COMSTOCK, Ent. Rept., U. S. Dept. Agric., 1880, p. 236; Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 40.

This species was found by the author on a lime-tree, in Kawasaki, near Tokyo. It is not at all common in Japan, in fact, it was not found in any other part of the Empire. A. Craw, in quarantine work, found it on deciduous magnolia from Japan some years ago.

### 33. Lecanium, sp.

PLATE XI, FIG. 65.

Of this scale but three female specimens were secured; one being infested by the hymenopterous parasites and another badly broken. The species could not be identified. Only the external characters will be given.

*Female Scale.*—Length 9 mm., width 9.5 mm., height 7.5 mm.; color dark shining brown, derm apparently thick; covered with white powder. Four raised cones on the dorsum. The scale, sloping toward the anterior end, has many raised, rather smooth ridges. The median groove distinct. The anal cleft deep.

This species was found by the author on *Kraunhia floribunda* (Fuji) in the grounds of the Yokohama Nursery, Yokohama.

Subfamily DIASPINÆ.

## Genus **Aspidiotus** *Bouché.*

### 34. Aspidiotus inusitatus *Green.*

*Aspidiotus inusitatus* GREEN, Coccidæ of Ceylon, p. 49.

This species was found by the author on bamboo in Kokura, Kiushiu. This is the first time it has been recorded from Japan.

### 35. Aspidiotus persearum *Ckll.*

*Aspidiotus persearum* COCKERELL, Entomologist, 1898, p. 240. CRAW, Rept. Calif. State Bd. Hort., 1897–98, p. 108.

This species was found by the author on *Trachycarpus excelsus* (Shuro) in Tarumi, Chikujo-gun, Kiushiu. Previous to this A. Craw found it in his quarantine work at San Francisco, on "Alligator pears" *(Persea gratissima)* from Honolulu, H. I. This is the first time it has been recorded from Japan.

### 36. Aspidiotus secretus *Ckll.* var. lobulatus *Mask.*

*Aspidiotus secretus* var. *lobulatus* MASKELL, Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241; Proc. & Trans. New Zealand Inst., Vol. XXX, 1897, p. 224.

This species was found by the author on many kinds of bamboo in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo and Akabane. It has been recorded on *Bambusa* sp., (Miyanoshita) Japan, by A. Koebele.

### 37. Aspidiotus trilobitiformis (?) *Green.*

*Aspidiotus trilobitiformis* GREEN, Indian Mus. Notes, IV, p. 4.

This species was found by the author in a garden in Minoshima, Wakayama-ken. The name of the host is unknown. This is the first time it has been recorded from Japan.

### 38. Aspidiotus duplex *Ckll.*

*Aspidiotus duplex* COCKERELL, Psyche, Supp., 1896, p. 20; Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 52; Bull. No. 6, T. S., Div. Ent., U. S. Dept. Agric., 1897, p. 20. CRAW, Rept. Calif. State Bd. Hort., 1895-96, p. 33.

This species was found by the author on *Rhus succidanea* (Haze-no-ki) in Yukubashi, Kiushiu, on *Eurya ochnacea* (Sakaki) in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo, and on *Thea japonica* (Tsubaki) in Yokohama. Originally described by Cockerell, from specimens sent to the Division of Entomology, U. S. Department of Agriculture, by O. Takabashi, Tokyo. A. Craw, San Francisco, also found this insect on the following plants from Japan: orange, camellia, azalea *Olea fragrans*, tea-plant, camphor, pæony, *Myrica rubra*, and rhododendron.

### 39. Aspidiotus duplex var. pæoniæ *Ckll.*

*Aspidiotus duplex* var. *pæoniæ* COCKERELL, Can. Ent., Vol. XXXI, 1899, p. 105.

This species appears to be a general feeder. It was found upon the following trees and plants: *Eurya ochnacea*

in Hikosan; *Thea japonica* in Akabane; *Rhododendron indicum* var. *kæmpferi* (Tsutsuji); *R. indicum* var. *macranthum* (Satsuki); *Ilex latifolia* (Taraya); *Clethra barbineros* (Ryobu); and *Thea sinensis* (Cha) in Tokyo. A. Craw, San Francisco, had previously recorded it on a pæony from Japan.

This scale is one of the worst pests of tea and ornamental plants. In many places the tea-plants were dying from the effects of the pest.

### 40. Aspidiotus perniciosus *Comst.*

*Aspidiotus perniciosus* COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 304. KUWANA, Cont. to Biol., The Hopkins Seaside Lab. of Leland Stanford Jr. Univ., No. XXV, 1901, pp. 1-14. SASAKI, Annot. Zool. Japan, Vol. III, 1901, pp. 165-173.

This scale was recorded by the author from many localities on the three main islands of the Japanese Empire: Kiushiu, Hondo and Hokkaido. On Kiushiu Island it was found on an old native pear-tree (about fifty years old), which was badly infested with the scale. The tree was standing alone at the back of a farm house, with no possible chance of its having come in contact with an infected tree. On the same island, near Kokura, was a pear orchard about five years old. The stock came from Tokyo, and was badly infested with the scale. In the spring of 1899 the owner dug up and burnt more than three hundred trees, but it was too late then, for the scale had already spread nearly all over the orchard. In Shiga-ken it was found on pear, apple, and quince trees in the grounds of the Agricultural Experiment Station. In Gifu-ken there are many small orchards, in every one of which the scale was found. In Tokyo it was found on pear-trees in the Mita Nursery and other places, on pear-trees in Kawasaki, and in Yokohama on pear-trees growing in a pot. In the northern part of Hondo the scale was found in orchards in Angio, Sendai, Morioka, Aomori, and Hirosaki; and in Hokkaido it was found in the apple orchard of the Agricultural College, Sapporo. Many of the trees were dying from the attack

of the scale. Since the author's return from Japan, Suguya Hori has written, saying that the scale has been found by him in some places in Hokurikudo. M. Nawa has also informed the author that he found it on nursery stock in Shikoku.

The scale was found upon the following hosts: pear, apple, peach, Japanese quince, currant, willow (*Salix gracilistyla*), *Pilea pumila*, *Pæonia moutan*.

The detailed data of this species are given in the author's report on "The San Jose Scale in Japan" (Contrib. to Biol. from the Hopkins Seaside Laboratory of Leland Stanford Jr. University, No. XXV, p. 1–14, 1901.).

### 41. Aspidiotus ulmi *Johns.*

*Aspidiotus ulmi* JOHNSON, Bull. Ill. State Lab. Nat. Hist., Vol. IV, 1896, p. 388; Entomological News, Vol. VIII, 1896, p. 152.

This species was found by the author on *Cycas revoluta*, in the grounds of the capitol of Hukuoka, and on two unknown hosts, one in Akabane and the other in the Nishigahara, Tokyo. This is the first time it has been recorded from Japan.

### 42. Aspidiotus cydoniæ *Comst.*

*Aspidiotus cydoniæ* COMSTOCK, Ent. Rept., U. S. Dept. Agric., 1880, p. 295.

This species was found by the author on fern (Kenchiyo) in the Yokohama Nursery, Yokohama. This is the first time it has been recorded from Japan.

### 43. Aspidiotus lataniæ *Sign.*

*Aspidiotus lataniæ* SIGNORET, Essai, 1868, p. 124.

This species was found by the author on *Abies firma* (Momi) in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo. Previous to this it had been found on tea-plant in Gifu, but this is the first time it has been recorded from Japan.

## 44. Aspidiotus cryptomeriæ, sp. nov.

PLATE XII, FIGS. 66–68.

*Scale of Female.*—The scale of the female is usually elliptical, flatly convex. Length 1.1 to 2. mm., width about 1. mm.; usual color grayish, subtransparent. The exuviæ are usually a little to one side of the center; straw color. The first skin usually shows the segmentation distinctly, length about .4 mm.; the second skin is more or less covered with secretion, length about .65 mm. Ventral scale a mere film applied to bark of plant.

*Female.*—The body of the mature female is rather flat, pale yellow, and oval in shape. The last segment is a little deeper yellow than the rest of the body, and presents the following characters:—

There are five groups of spinnerets. The anterior group contains four to five; the anterior lateral, seven to eight; the posterior laterals four to six. There are three pairs of well developed lobes. The first and second lobes of lateral side are abruptly narrowed toward their posterior extremities from about one-half their length; the third pair is much smaller than the first two pairs, and the lateral sides are sloping and very minutely serratulate. The plates are well developed; they are not much longer than the lobes, and are fringed; there are two small ones between the median lobes; those of each side are as follows,—two between the first and second lobes, three between second and third lobes, usually seven laterad of the third lobe. The spines are prominent; the first pair is situated near the lateral margin of the base of the first lobes, the second and third, about the middle of the bases of the second and third lobes; two or more spines laterad of the base of the third lobe.

*Scale of Male.*—The scale of the male is elongated, with the larval skin nearly central; color grayish, same as female in texture; larval skin straw color. Length about 1. mm., width .6 mm.

This species was found by the author on *Cryptomeria japonica* (Sugi) in Gifu-ken. It is allied to *Aspidiotus destructor* Sign., but the female scale of the new species is elliptical in form, and the exuviæ in one side of the center, and the third pair of lobes of last abdominal segment of female is much smaller.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 45. Aspidiotus jordani, sp. nov.

PLATE XII, FIGS. 69–71.

*Scale of Female.*—The scale of the female is circular and flat; about 1.5 to 2.5 mm. in diameter. The general color of the scale is dingy brown,

conforming usually to the color of the under side of the leaves to which it is attached. The exuviæ are in the center, and are covered with secretion. The first skin is a pale straw color, .4 mm. in length; second skin orange-yellow, .85 mm. long.

*Female.*—The body of the mature female is subcircular, usually from 1 to 1.5 mm. long, and .75 mm. wide; color brown. Presents the following characters:—

There are four groups of spinnerets. The anterior laterals vary from eleven to fourteen; the posterior laterals from seven to nine. There are three pairs of well developed lobes; the median pair commonly notched on the inner margin, sloping on the lateral margin, and very minutely serratulate; the second pair is smaller, and the third still smaller; the lateral margin of the second and third pair of lobes is sloping, and very minutely serratulate. The margin of the ventral aspect of the segment is deeply incised between the lobes. The parts of the body-wall forming the margin of these incisions are very much thickened. The plates are distinct, not longer than the lobes, fringed. There are two small ones between the median lobes; those of each side are as follows: two between the first and second lobes, three between second and third lobes, five or six laterad of the third lobe. The spines are prominent. The first, second, and third spines are situated near the lateral margin of the bases of the first, second, and third lobes; two more spines laterad of the base of the third lobe.

*Scale of Male.*—The scale of the male is circular, flat, and the same color as that of the female; about 1. mm. in diameter.

This species was found by the author on *Quercus* sp. Angio, Saitama-ken. The scale is extremely inconspicuous, as it lives beneath the epidermis on the under side of the leaf.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 46. Aspidiotus (Chrysomphalus) aurantii *Mask.*

*Aspidiotus (Chrysomphalus) aurantii* MASKELL, Trans. & Proc. New Zealand Inst., Vol. XI, 1878, p. 199. COCKERELL, Bull. No. 6, T. S., Div. Ent., U. S. Dept. Agric., 1897, p. 29.

This species was found by the author on a number of cultivated plants, namely: orange-tree and *Podocarpus chinensis*, in Wakayama-ken; on *Acacia* and the tea-plant in Yokohama; and on *Podocarpus chinensis* in Tokyo. Previous to this O. Takahashi, Tokyo, found it on *Podocarpus* in Japan.

## 47. Aspidiotus (Chrysomphalus) ficus *Ashm.*

*Aspidiotus (Chrysomphalus) ficus* RILEY & ASHMEAD, Amer. Ent., 1880, p. 267. CRAW, Rept. Calif. State Bd. Hort., 1895–96, p. 34. MASKELL, Proc. & Trans. New Zealand Inst., Vol. XXIX, 1896, p. 297; Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241.

This species was found by the author on *Asparagus plumosus*, *Machilus thunbergii* (Inu-gusu), and Mango in Tokyo; on *Aspidistra lurida* and *Ligustrum japonicum* (Nezumi-mochi) in Yokohama. A. Craw, San Francisco, had previously recorded it on *Ilex latifolia* and *Aspidistra lurida* from Japan, and A. Koebele had also found it on *Quercus cuspidata* in Japan.

## 48. Aspidiotus (Chrysomphalus) kelloggi, sp. nov.

PLATE XII, FIGS. 72–74.

*Scale of Female.*—The scale of the female is circular, convex, with exuviæ on one side of the center; the portion of the first skin is indicated by a nipple-like prominence which is coal black; the part of the scale covering the second skin is black; the remainder of the scale is brown, varying from a reddish brown to almost black. The scale measures 2 mm. to 3 mm. in diameter. The ventral scale is distinct; dark brown.

*Female.*—The body of the mature female is globose, pale yellow, the last abdominal segment is yellow, and presents the following characters:—

There are four groups of spinnerets. Anterior laterals vary from 11 to 17; the posterior laterals from 12 to 14. The number varies on opposite sides of the same individual. There are three pairs of well developed lobes; they are subequal, the lateral sides are sloping and serratulate. Plates distinct, small, shorter than lobes, fringed. Between the first pair of lobes are two small plates; between the first and second lobes of each side are two, and between the second and third lobes are three similar plates; one plate laterad of the third lobe. The body-wall is furnished with six thickenings on each side of the meson. These thickenings are long, somewhat club-shaped, the anterior part being enlarged and rounded. There is one terminating the base of each margin of each lobe. Those ending at the base of the lateral margins of the first lobes, and between the second and third lobes, are much longer than the others. There are three spines, one at the middle of the base of each lobe, and two more beyond the third lobe.

Found by the author in Higuma-yama, Chikujo-gun, Kiushiu. The name of the host is unknown.

This species is allied to *Aspidiotus sphærioides* Ckll., but may be easily distinguished from that species by having only two pairs of spinnerets.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus **Diaspis** *Costa.*

### 49. Diaspis pentagona *Targ.-Tozz.*

*Diaspis patelliformis* SASAKI, Bull. Agric. College, Tokyo, 1894, pp. 107–124.
*Diaspis amygdali* TRYON. CRAW, Rept. Calif. State Board Hort., 1895–96, p. 38.
*Diaspis amygdali* var. *rubra* MASKELL, Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 228.
*Diaspis amygdali* WEBSTER, Can. Ent., Vol. XXX, 1898, p. 79 and Vol. XXXI, 1899.
*Diaspis amygdali* COOLEY, Can. Ent., Vol. XXX, 1898, p. 232.
*Diaspis lanatus* MORG. & CKLL. CRAW, Rept. Calif. State Bd. Hort., 1895–96, p. 29; and 1897–98, p. 106.

This scale insect is widely distributed, being found in nearly every province of Japan. It is the worst pest of the mulberry, fruit, and ornamental trees. In many places the mulberry-trees were dying from its effects. The insect generally attacks the lower part of the trunk, near the ground, although it often covers the entire surface of limbs and branches, as well as the trunk, and often can be seen from a great distance. It predominates in shady places which are not much exposed to sun or wind.

A. Craw, San Francisco, has recorded this insect from time to time on plum, persimmon, peach, cherry, and walnut-trees from Japan; Prof. Webster, Wooster, Ohio, has recorded it on flowering cherry *(Prunus pendula)*, and *P. pseudo-cerasus*, from that country; and Mr. Cooley, Mass., also found this insect on *Prunus mume* and *P. subhirtella*, which were also imported from Japan.

The author found it on the following hosts: *Juglans sieboldeana* (Onigurumi), *Prunus pseudo-cerasus* var. *sieboldi* (Yoshino-zakura), *Prunus buergeriana* (Inn-zakura), *Ulmus* sp., mulberry-tree (Kuwa), *Paulownia imperialis* (Kiri), *Zanthoxylum piperitum* (Sansho), *Prunus persica* var. *vulgaris* (Momo), cherry-tree (Sakura), pear-tree (Nashi), grape (Budo), *Diospyros kaki* (Kaki), *Broussonetia kazinoki*

(Kozo), (Some-Kusagi), *Elæagnus macrophylla* (Gumi), *Pterocarya rhoifolia* (Sawa-gurumi), *Orixa japonica* (Ko-Kusagi).

The size, shape, and color of the female scales differ more or less on different hosts, although these variations are also due to the stage of the insects and to surrounding conditions. The female scales on *Prunus mume* and cherry-tree are larger, flatly convex, and ash-gray with yellowish exuviæ; on the mulberry-trees and on *Diospyros kaki* they are almost equal in size to those on *P. mume*, and are the same in general appearance, except that they are of a lighter color; on other hosts they are more convex and smaller. When the scale is young the exuviæ are usually reddish and the scale snowy white. Such differences may be sufficient to base subspecies upon, but upon examining the female with the compound microscope, there is no difference in the characters upon which the classification is based.

### 50. Diaspis crawii *Ckll.*

*Diaspis crawii* COCKERELL, Psyche, Vol. VIII, 1897, p. 190. CRAW, Rept' Calif. St. Bd. Hortic., 1897–98, p. 111

This species was found by the author on *Elæagnus umbellata*, in Chikujo-gun, Kiushiu, Japan. It has been recorded on a tree from China by Mr. A. Craw, San Francisco.

## Genus Aulacaspis *Ckll.*

### 51. Aulacaspis rosæ *Bouché.*

*Diaspis rosæ* COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 312. MASKELL, Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241.

This species was found by the author on rose-bushes in Yokohama, Gifu, and Aichi-ken. Previous to this A. Koebele had found it on *Elæagnus macrophylla* and *Trachelospermum jasminoides*, in Japan.

## Genus Leucaspis *Sign.*

### 52. Leucaspis japonica *Ckll.*

*Leucaspis japonica* COCKERELL, Psyche, Vol. VIII, 1897, p. 53. CRAW, Rept. Calif. State Bd. Hort., 1897–98, p. 111.

This species was found by the author on apple-trees in Sendai, and Sapporo, on maple and *Pæonia moutan* (Botan) in Hirosaki, and on the same host in Yokohama. A. Craw, San Francisco, had already recorded it on broom, *Magnolia souleana*, and *Acer* sp. from Japan. It is extremely numerous in Sapporo, and no doubt is injurious to the fruit trees also.

### 53. Leucaspis bambusæ, sp. nov.

PLATE XIII, FIGS. 75–81.

*Scale of Female.*—Length usually 2 to 3 mm.; nearly parallel-sided, straight, though sometimes curved, gradually broadened posteriorly; convex, and moderately thick in texture; color snow-white; exuviæ about 1. mm. long; first skin light brown, elliptical; second, slightly darker.

*Female.*—Body very slender, narrower toward anterior end and broader toward posterior end. Abdominal segments distinct. The last segment is yellowish and presents the following characters:—

There are five groups of spinnerets. The anterior group contains five, the anterior laterals nine to eleven, and the posterior lateral seven to nine. There are two pairs of well developed and conspicuous lobes; those of the median pair parallel with each other, each one being furnished with a notch on each side; second pair flat, each lobe being divided into two nearly equal lobules, the larger of which is mesal, each lobule being furnished with a notch on each side. Plates shorter than the lobes, but very distinct, forked at the tip; two between median lobes, one between median and second lobes, three between second lobe and gland spine. Gland spines are prominent; formula, 1, 1, 2—3. First spine on the lateral margin of the median lobe, second spine at the middle of the margin of the second lobe, and third spine on the margin laterad of the second lobe.

*Newly Hatched Larva.*—Length .3 mm., width .11 mm.; elliptical; pale in color; distinctly segmented. Mouth-parts large; rostral loop long. Antennæ and legs well developed. Antennæ six-segmented; formula, 3, 6 (1, 2, 4, 3); segment 3 much the longest. Three pairs of legs subequal; femur very broad; tarsus short. Caudal end of body with two long hairs.

This species was found by the author on bamboo, in Kokura, Kiushiu.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus **Hemichionaspis** *Ckll.*

### 54. Hemichionaspis aspidistræ *Sign.*

*Hemichionaspis aspidistræ* SIGNORET, Essai, 1869, p. 443.
*Chionaspis aspidistræ* CRAW, Rept. Calif. State Bd. Hort., 1895–96, p. 35. COOLEY, Special Bull. Hatch. Exper. Station, Mass., 1899, p. 45. (The Coccidæ, Genera Chio. and Hemichio.)

This species was found by the author on *Aspidistra lurida* (Haran) and on an orchid in the Yokohama Nursery, Yokohama. A. Craw, San Francisco, had already recorded it on *A. lurida* from Japan.

### 55. Hemichionaspis minor *Mask.*

*Hemichionaspis minor* MASKELL, Trans. & Proc. New Zealand Inst., Vol. XVII, 1884, p. 33.

This species was found by the author on orange-trees in Kiushiu and Wakayamao-ken. The male scales are usually grouped on the under side of leaves or small twigs. This is the first time it has been recorded from Japan.

### 56. Hemichionaspis minor var. strachani *Cooley.*

*Hemichionaspis minor* var. *strachani* COOLEY, Special Bull. Hatch Exper. Station, Mass., 1899, p. 54.

This species was found by the author on *Cycas revoluta*, in the grounds of the Capitol of Hukuoka City. This is the first time it has been recorded from Japan.

## Genus **Chionaspis** *Sign.*

### 57. Chionaspis euonymi *Comstock.*

*Chionaspis euonymi* COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 313. CRAW, Rept. Calif. State Bd. Hort., 1895–96, p. 38.

This species was found by the author on *Euonymus japonica* (Masaki) in Sapporo and in Yokohama. A. Craw

San Francisco, had already recorded it on the same host from Japan.

### 58. Chionaspis bambusæ *Ckll.*

*Chionaspis bambusæ* COCKERELL, Psyche, Supp., 1896, p. 21; Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 54.

This species was found by the author on the leaves of bamboo, in Akabane. Previous to this O. Takahashi, Tokyo, sent specimens of the same to the Division of Entomology, U. S. Department of Agriculture, from which Professor Cockerell described the species.

### 59. Chionaspis (?) hikosani, sp. nov.

PLATE XIII, FIGS. 82 AND 83.

*Scale of Female.*—Very long and slender; length about 2.5 mm., width .4 mm.; sides straight, parallel, sometimes curved; color snow-white. First skin elliptical, almost transparent; median longitudinal ridge distinct; antennæ prominent; second skin very much longer, slightly convex, posterior end yellowish; exuviæ .75 mm. long.

*Female.*—Adult female very small; length less than 1 mm., width about .3 mm. Last abdominal segment presents the following characters:—

One pair of median lobes, short, diverging, and slightly notched on inner margin. One large gland-spine laterad of each median lobe. The plate-like margins are broad, rounded, and serrulate. Second pair of gland-spines rising from lateral side of the plate-like margin; the third pair of gland-spines is very conspicuous, being separated by a plate-like margin; first pair of spines on each side of median lobe near base; second pair of spines on plate-like margin near the lateral margin; third pair near the base of third pair of gland-spines. Spinnerets wanting.

This species was found by the author on *Phyllostachys bambusoides* (Ya-dake) at Hikosan, Kiushiu.

C. L. Marlatt, who has examined the specimens, says: "The structure of the female somewhat approaches genus *Leucaspis*, but the scale is entirely different from the *Leucaspis* type. To properly place it, one should have the male, which is wanting."

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## 60. Chionaspis platani *Cooley.*

*Chionaspis platani* COOLEY, Special Bull. Hatch Exper. Station, Mass., 1899, p. 36. (The Coccidæ, Genera Chio. and Hemichio.)

This species was found by the author on *Rhus* sp. in Aomori City. This is the first time it has been recorded from Japan.

## 61. Chionaspis wistariæ *Cooley.*

*Chionaspis wistariæ* COOLEY, Can. Ent., Vol. XXIX, 1897, p. 290; Special Bull. Hatch Exper. Station, Mass., 1899, p. 39. (The Coccidæ, Genera Chlo. and Hemichio.) CRAW, Rept. Calif. State Bd. Hort., 1897–98, p. 110.

This species was found by the author on *Alnus japonica* (Hanno-ki) *Salix babylonica* (Shidare-yanagi), and *Salix* sp. in Gifu-ken. A. Craw has also recorded it on wistaria from Japan.

## 62. Chionaspis colemani, sp. nov.

PLATE XIII, FIG. 84.

*Scale of Female.*—Length about 2 to 2.5 mm., width about 1.5 mm. Decidedly broadened posteriorly; moderately strong in texture; color, pale straw-white. Exuviæ, 1 mm. long, first skin about .3 mm. long, elliptical, slightly broadened posteriorly; a median longitudinal ridge; antennæ prominent; color transparent. Second skin, large; slightly convex; posterior end orange-yellow.

*Female.*—Body of the female rather long and slender; length 1.2 to 2 mm.; width .5 to 1 mm.; elliptical in outline. The last abdominal segment presents the following characters: the lobes are very inconspicuous; the median lobes almost invisible, pointed; the second lobes are very small, being simply an angular projection of the body-wall; the third lobes are about twice as large as the second and project a little beyond the margin of the segment. The second and third lobes are more or less ciliated. Many suboval, thickened bodies in near the margin are very conspicuous as shown in the figure. The gland-spines are arranged as follows: 1, 1, 2, 1, 1, 1; they are similar except that the last one is forked; one between first and second lobes, one between second and third lobes, two laterad of third lobes and three more beyond that. Spines are prominent, extending beyond plates. The first pair are situated near the lateral margin of the first lobes; the second about the lateral margin of the base of the outer lobules of the second lobes; the third pair on the lateral margin of the third lobes; another pair of spines outside of the third lobes. There are five groups of spinnerets; the anterior group contains seven to ten; the anterior laterals, twelve to sixteen; the posterior laterals, nine to fifteen.

*Scale of Male.*—Length about .8 mm.; slender, convex; color grayish white.

*Egg.*—Length about 2 mm.; oval; pale in color.

Found by the author on bamboo, Hikosan, in Kiushiu, and named in honor of Mr. G. A. Coleman of Stanford University.

This new species is allied to *C. bambusæ* Ckll., but is distinguished from it by having a rather short and very broad female scale, with many ridges on the dorsal aspect, as in a certain mollusca. There is also a difference in the arrangement of the gland-spines and in the shape of the plates.

Prof. R. A. Cooley of Montana Agricultural Station, who kindly examined my specimens, writes as follows:—

"The specimens you sent me were rather troublesome. I made several attempts at determining them and even went so far as to write you a letter which I later withheld. I have again reviewed the matter to-day [Nov. 6, 1901] and after an extended comparison feel sure that your species is a new one.

"It is near *C. bambusæ* Ckll., and is also near *C. doxyli* Mask.

"While we cannot do better than to place it in the genus *Chionaspis* at present, it is certain that it does not belong to *Chionaspis* proper."

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

## Genus **Parlatoria** *Sign.*

### 63. Parlatoria pergande *Comstock.*

*Parlatoria pergande* COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 327. CRAW, Rept. Calif. State Bd. Hort., 1897–98, p. 98.

This species was found by the author on orange-trees, in Kokura. A. Craw, San Francisco, has also recorded it on the same host from Japan.

### 64. Parlatoria pergande, var. theæ *Ckll.*

*Parlatoria pergande* var. *theæ* COCKERELL, Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 55; Psyche, Supp., 1896, p. 21.

This species was found by the author on *Acer cratægifolium* (Uri-kaede) in Kyoto, on *Acer pictum* var. *mono*

(Itaya-kaede) in Osaka, on *Diospyros kaki* in Chikujo-gun, Kiushiu, on rose in Gifu-ken, on apple in Tokyo, on *Cornus macrophylla* (Mizuki) and *Osmanthus fragrans* (Mokusei) in the Yokohama Nursery, Yokohama, and on *Hibiscus syriacus* (Mukuge) in Sendai.

This scale is widely distributed and is very destructive to the ornamental trees and plants.

### 65. Parlatoria proteus *Curt.*

*Parlatoria proteus* CURT. SIGNORET, Essai, 1867, p. 450. CRAW, Rept. Calif. State Bd. Hort., 1897-98, p. 112. MASKELL, Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241.

This species was found by the author on *Angræcum falcatum* (Furan) in Yokohama. A. Craw, San Francisco, has recorded it on orange-tree, and A. Koebele on camellia and *Machilus* from Japan.

## Genus **Fiorinia** *Targ.*

### 66. Fiorinia fioriniæ (?) *Targ.-Tozz.*

*Fiorinia fioriniæ (?)* TARGET-TOZZINI. SIGNORET, Essai, 1896, p. 449.

This species was found by the author on fern in the Yokohama Nursery, Yokohama. A. Craw, San Francisco, has also recorded it on camellia from Japan.

### 67. Fiorinia fioriniæ *Targ.-Tozz.* japonica, var. nov.

This variety differs from the typical *F. fioriniæ* by having numerous spinnerets, particularly in the lateral groups:—

Anterior group, 3 to 4; anterior lateral groups, 16 to 22; posterior lateral groups, 24 to 27. The other characters are identical.

Found by the author on *Podocarpus chinensis* (Maki) in the grounds of the Nishigahara Experiment Station, Tokyo, and Gifu-ken, and on *Pinus* sp. in Shiga-ken.

## Genus **Mytilaspis** *Sign.*

### 68. **Mytilaspis pomorum** *Bouché.*

*Mytilaspis pomorum* Bouché. Comstock, Ent. Rept. U. S. Dept. Agric., 1880, p. 325.

This species was found by the author on apple, *Mespilus, cuneata*, and currant in Sapporo, on willow in Aomori, on apple in Sendai and Morioko, on orchid in Yokohama, and on *Ilex crenata* (Inu-tsuge) in Hikosan. There is considerable variation in color, those on *Mespilus cuneata* (Sanzashi) being light brown, those on currant dark brown, and those on apple grayish. This insect though not recorded has been known in Japan for some time.

### 69. **Mytilaspis pomorum** *Bouché* **japonica**, var. nov.

*Scale of Female.*—Dark with yellowish brown exuviæ.

*Female.*—Yellowish in color; posterior region of the body very much wider than the thoracic region. Anterior group of spinnerets consists of four to eight, anterior laterals, eleven to sixteen, and posterior laterals, seven to twelve. The lobes are of the same shape as those of the typical *M. pomorum* but much smaller. The notches on the lobes are not quite so distinct as in the type.

This species was found by the author on *Abies firma* (Inu-kaya) in Hikosan, Kiushiu.

### 70. **Mytilaspis euryæ**, sp. nov.

Plate XIII, Figs. 85-89.

*Scale of Female.*—Length 3-4 mm.; long, narrow, widened posteriorly, straight, sometimes curved; color dark brown. First skin pale brown, showing segmentation distinctly, second skin more or less covered by the secretion.

*Female.*—Length 1.35 mm., width .6 mm.; color pale brown, posterior region yellow. The last abdominal segment presents the following characters:—

There are five groups of spinnerets. The anterior group consists of four to five, anterior lateral, seven to nine, and posterior lateral, seven to eight. Lobes small; median lobes rounded, usually notched on the lateral margin near tip; second pair flat, each lobe being divided into nearly equal lobules, the larger of which is mesad. Plates simple, spiny and tapering; two between meso and second lobes, three outside of the second lobes. Spines

inconspicuous; the first pair situated near the lateral margin of the base of the first lobes; the second, about the middle of the base of the second lobes; the third, laterad of the base of the third lobes.

This species was found by the author on *Eurya ochnacea* in Hikosan, Kiushiu.

Type in the Entomological Collection of Leland Stanford Jr. University, and co-types in the author's collection.

### 71. Mytilaspis gloverii *Pack.*

*Mytilaspis gloverii* PACKARD. COMSTOCK, Ent. Rept. U. S. Dept. Agric., 1880, p. 323.

This species was found by the author on orange in Gifuken and orange leaves and twigs in Kiushiu and Wakayama-ken. The scales on the twigs were very much darker than those on the orange. This is the first time it has been recorded from Japan.

### 72. Mytilaspis citricola *Pack.*

*Mytilaspis citricola* PACKARD. MASKELL, Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241.

This species was found by the author on orange-tree in Chikujo-gun, Kiushiu, and on *Cercidiphyllum japonicum* (Katsura) in Hirosaki. A. Koebele has also recorded it on *Taxus cuspidata* (Ichii) in Japan.

### 73. Mytilaspis newsteadi *Sulc.*

*Mytilaspis newsteadi* SULC, S. B. bohm. Gesell., 1895, No. XLIX, pp. 8 and 19.

This species was found by the author on the leaves of *Thea japonica*, Tokyo. This is the first time it has been recorded from Japan.

### 74. Mytilaspis newsteadi *Sulc.* tokionis, var. nov.

This variety differs from the typical *M. newsteadi*, first, in being larger and more slender; second, in having the median lobes more or less diverged and each side abruptly

narrowed, then prolonged more or less into a point, with the margins slightly serratulate.

The male scale is narrower than the typical *M. newsteadi*.

This species was found by the author on *Codiæum* sp. in a green-house in Tokyo. It is a very destructive pest, particularly to the above named plant.

### 75. Mytilaspis crawii *Ckll.*

*Mytilaspis crawii* COCKERELL, Psyche, Supp., 1896, p. 21; Bull., T. S., No. 4, Div. Ent., U. S. Dept. Agric., 1896, p. 45. CRAW, Rept. Calif. State Bd. Hort., 1895-96, p. 41. MASKELL, Ent. Mon. Mag., Vol. XXX, 1897, p. 241.

This species was found by the author on *Quercus* (Pasania) *cuspidata* (Shii) in Tokyo. Previous to this, A. Craw, San Francisco, had recorded it on the same host and on *Elæagnus* from Japan.

## Genus Poliaspis *Mask.*

### 76. Poliaspis pini *Mask.*

*Poliaspis pini* MASKELL, Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 231; Ent. Mon. Mag., Vol. XXXIII, 1897, p. 242.

This species is widely distributed, being found nearly all over the Empire. The author found it on the following plants: *Pinus austriaca*, *Pinus* sp., *Pinus thunbergii*, *Torreya nucifera*, *Abies firma*, and *Picea bicolor*, in the grounds of the Nishigahara Agricultural Experiment Station, Tokyo; on *Pinus* sp., Kubotesan, Kiushiu; on *Pinus* sp. in Shigaken, and on *Podocarpus chinensis* in Wakayama-ken. A. Koebele has recorded it on *Pinus densiflora*, Miyanoshita, Japan.

The specimens collected in Wakayama-ken, on *Podocarpus chinensis*, are slightly different from the others, although the differences are not sufficient to make a new species or variety. The female scale is light brown, narrower than the others. The spinnerets are fewer in number, particularly those of the posterior lateral groups, and of the middle one of the anterior row of three groups.

## III. LIST OF COCCIDÆ RECORDED FROM JAPAN NOT INCLUDED IN THE FOREGOING LIST.

*Dactylopius syringæ* MASK., Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 246.

*Dactylopius edgeworthiæ* CKLL., Am. Nat., Vol. XXX, 1897, p. 589.

*Dactylopius virgatus* CKLL. (=*D. ceriferus* NEWST., Ind. Mus. Notes, Vol. III, 1894, p. 24); Can. Ent., Vol. XXX, 1898, p. 222; Trans. & Proc. New Zealand Inst., Vol. XXIX, 1896, p. 320.

*Phenacoccus pergandei* CKLL., Psyche, Supp., 1896, p. 17; Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 55.

*Sphærococcus populi* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 244; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 248.

*Asterolecanium (Planchonia) delicata* GREEN, Ent. Mon. Mag., Vol. XXXIII, 1897, p. 243.

*Asterolecanium variolosum* var. *japonicum* CKLL., Psyche, Vol. IX, 1900, p. 71.

*Lecanium notatum* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 243; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 238.

*Lecanium cerasarum* CKLL., Psyche, Vol. IX, 1900, p. 71.

*Ceronema japonicum* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 243.

*Aspidiotus secretus* CKLL., Psyche, Supp., 1896, p. 20; Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 51.

*Aspidiotus greenii* CKLL. (=*A. lataniæ*), Ent. Mon. Mag., Vol. XXXIV, 1898, p. 184; Bull. No. 6, T. S., Div. Ent., U. S. Dept. Agric., 1897, p. 27; Rept. Calif. State Bd. Hort., 1897–98, p. 102.

*Aspidiotus perniciosus* var. *andromelas* CKLL., Bull. No. 6, T. S., Div. Ent., U. S. Dept. Agric. 1897, p. 20; Rept. Calif. State Bd. Hort., 1897–98, p. 107.

*Aspidiotus perniciosus* var. *albopunctatus* CKLL., Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 43; Psyche, Supp., 1896, p. 20; Rept. Calif. State Bd. Hort., 1895–96, p. 33.

*Aspidiotus cryptoxanthus* CKLL., Psyche, Vol. IX, 1900, p. 71.

*Aspidiotus setiger* MASK., Trans. & Proc. New Zealand Inst., Vol. XXIX, 1896, p. 298.

*Aspidiotus bambusarum* CKLL., Psyche, Vol. VIII, 1897, p. 191; Rept. Calif. State Bd. Hort., 1897–98, p. 108.

*Aspidiotus aurantii* var. *citrinus* COQU., Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 40.

*Aulacaspis rosæ* var. *spinosa* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 228.

*Diaspis auranticolor* CKLL., Can. Ent., Vol. XXXI, 1899, p. 107.

*Aonidia elæagnus* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 227.

*Chionaspis chinensis* CKLL., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 242; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 231; Rept. Calif. State Bd. Hort., 1895–96, p. 37.

*Chionaspis eugeniæ* MASK., Trans. & Proc. New Zealand Inst., Vol. XXIX, 1896, p. 306.

*Chionaspis latus* CKLL. (=var. of *C. aspidistræ*), Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 53; Psyche, Supp., 1896, p. 21.

*Chionaspis aucubæ* COOLEY, Can. Ent., Vol. XXIX, 1897, p. 279.

*Chionaspis difficilis* CKLL., Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 42; Psyche, Supp., 1896, p. 21; Rept. Calif. State Bd. Hort., 1895–96, p. 38.

*Chionaspis vitis* GREEN, Indian Mus. Notes, Vol. IV, p. 3.

*Chionaspis graminis* GREEN, Indian Mus. Notes, Vol. IV, p. 3; Ent. Mon. Mag., Vol. XXXIII, 1897, p. 242.

*Chionaspis latissima* CKLL., Can. Ent., Vol. XXIX, 1897, p. 282; Rept. Calif. State Bd. Hort., 1897–98, p. 110; Calif. Fruit Grower, June 5, 1897, pp. 4 & 5.

*Chionaspis citri* COMST., Rept. Calif. State Bd. Hort., 1895–96, p. 38.

*Parlatoria proteus* var. *virescens* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241; Trans. & Proc. New Zealand Inst., Vol. XXIX, 1896, p. 300.

*Parlatoria theæ* var. *euonymi* CKLL., Am. Nat., Vol. XXXI, 1897, p. 591; Rept. Calif. State Bd. Hort., 1897–98, p. 112.

*Parlatoria theæ* var. *viridis* CKLL., Bull. No. 4, T. S., Div. Ent., U. S. Dept. Agric., 1896, p. 43; Psyche, Supp., 1896, p. 21; Rept. Calif. State Bd. Hort., 1895–96, p. 42.

*Fiorinia signata* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 242; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 231.

*Fiorinia tenuis* MASK., Ent. Mon. Mag., Vol. XXXIII, 1897, p. 242; Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 232.

*Ischnaspis filiformis* DOUGL. (=*I. longirostris* SIGN.), Ent. Mon. Mag., Vol. XXIV, 1897, p. 242; Rept. Calif. State Bd. Hort., 1895–96, p. 40; Ent. Mon. Mag., Vol. XXXIII, p. 21.

*Mytilaspis machili* MASK., Trans. & Proc. New Zealand Inst., Vol. XXX, 1897, p. 230.

*Mytilaspis crawii* var. *canaliculata* MASK., Trans. & Proc. New Zealand Inst., Vol. XXIX, 1896, p. 304; Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241.

*Mytilaspis pallida* GREEN, Ent. Mon. Mag., Vol. XXXIII, 1897, p. 241.

*Mytilaspis pallida* var. *maskelli* CKLL., Rept. Calif. State Bd. Hort., 1897–98, p. 112.

STANFORD UNIVERSITY,
CALIFORNIA,
September, 1901.

## EXPLANATION OF PLATE VII

*Monophlebus carpulentus*, sp. nov.

Fig. 1. Dorsal aspect of female.
Fig. 2. Antenna of female.
Fig. 3. Leg of female; 3a, claw.

*Saissetia quercus*, sp. nov.

Fig. 4. Ventral aspect of female.
Fig. 5. Antenna of female.
Fig. 6. Leg of female.
Fig. 7. Posterior segment of larva.
Fig. 8. Antenna of larva.

*Kermes wilsoni*, sp. nov.

Fig. 9. Scales on a twig.
Fig. 10. Antenna of female.
Fig. 11. Leg of female.
Fig. 12. First larval stage, ventral aspect.
Fig. 13. Antenna of the same.
Fig. 14. Leg of the same; 14a, claw.
Fig. 15. Posterior margin of the same.

3
3a

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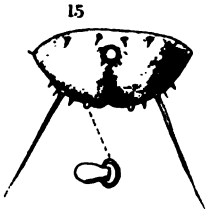
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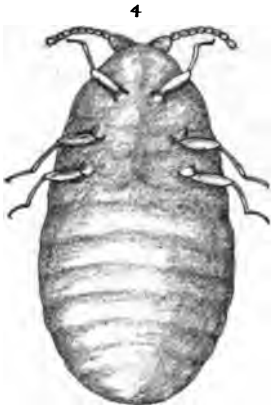
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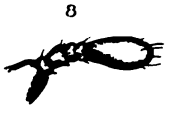
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## EXPLANATION OF PLATE VIII.

*Kermes nawæ*, sp. nov.

Fig. 16. Scale on a twig.
Fig. 17. Antenna of female.
Fig. 18. Leg of female.
Fig. 19. Ventral aspect of first larval stage.
Fig. 20. Antenna of first larval stage.
Fig. 21. Leg of first larval stage; 21*a*, claw.
Fig. 22. Posterior end of first larval stage.

*Eriococcus japonicus*, sp. nov.

Fig. 23. Female sacs and male cocoons on a twig.
Fig. 24. Antenna of female.
Fig. 25. Posterior end of female.

*Eriococcus onukii*, sp. nov.

Fig. 26. Female scale on a twig.
Fig. 27. Dorsal aspect of female.
Fig. 28. Ventral aspect of female.

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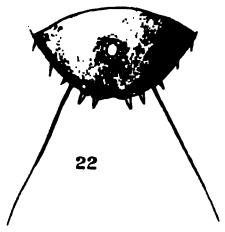
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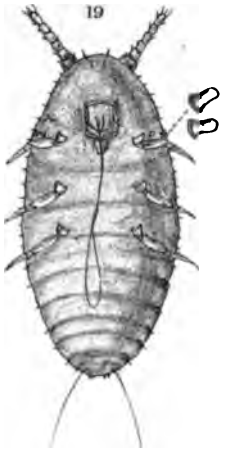
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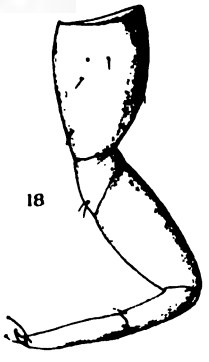
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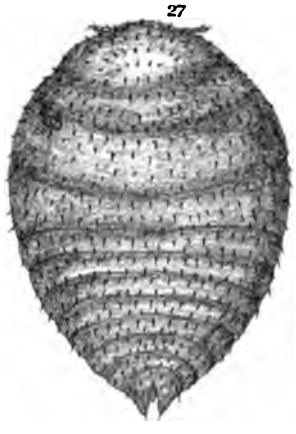
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## EXPLANATION OF PLATE IX.

*Eriococcus onukii*, sp. nov.

Fig. 29. Antenna of female.
Fig. 30. Leg of female.
Fig. 31. Dorsal spines of female.
Fig. 32. Antenna of first larval stage.
Fig. 33. Leg of first larval stage.

*Dactylopius comstocki*, sp. nov.

Fig. 34. Antenna of female.
Fig. 35. Leg of female.

*Dactylopius pini*, sp. nov.

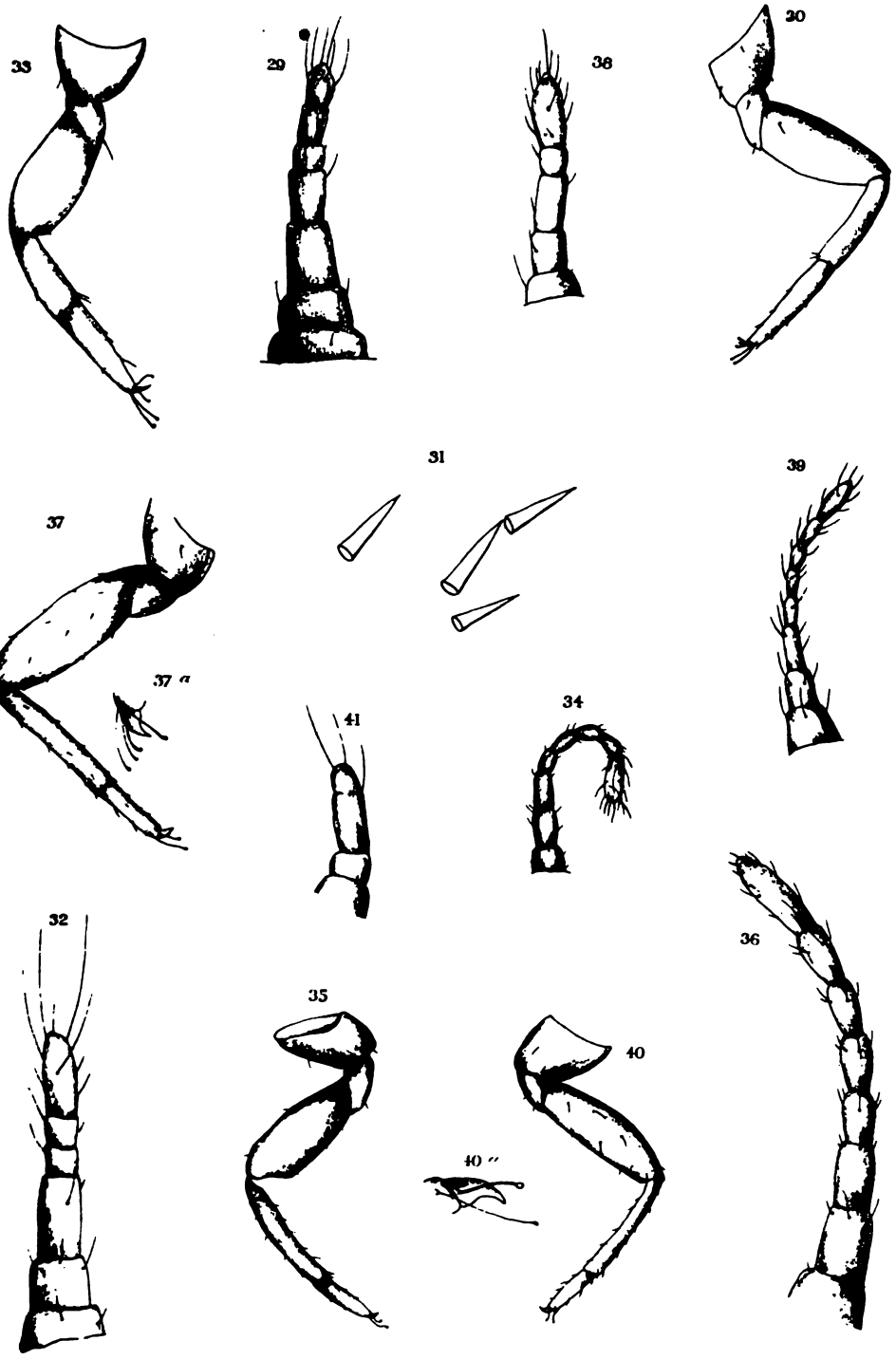
Fig. 36. Antenna of female.
Fig. 37. Leg of female; 37*a*, claw.
Fig. 38. Antenna of first larval stage.

*Dactylopius kraunhiæ*, sp. nov.

Fig. 39. Antenna of female.
Fig. 40. Leg of female; 40*a*, claw.

*Sphærococcus parvus* MASK.

Fig. 41. Antenna of first larval stage.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37 a
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40 a
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## EXPLANATION OF PLATE X.

*Pulvinaria psidii* MASK.

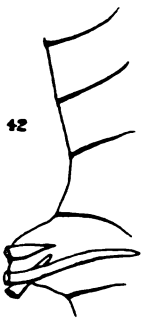
Fig. 42. Marginal spines of female.

*Pulvinaria aurantii* CKLL.

Fig. 43. Marginal spines of female.

*Pulvinaria horii*, sp. nov.

Fig. 44. Female scales on a host.
Fig. 45. Marginal spines of female.
Fig. 46. Antenna of female.
Fig. 47. Leg of female.
Fig. 48. Ventral aspect of first larval stage.
Fig. 49. Antenna of first larval stage.
Fig. 50. Leg of first larval stage.
Fig. 51. Marginal spines of first larval stage.
Fig. 52. Anal triangular plates of first larval stage.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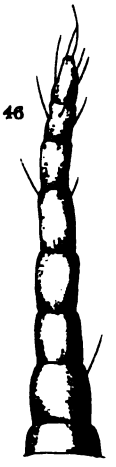
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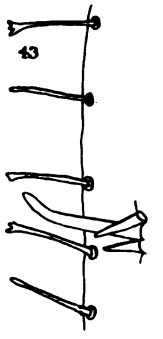
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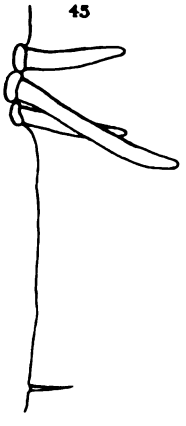
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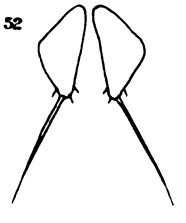
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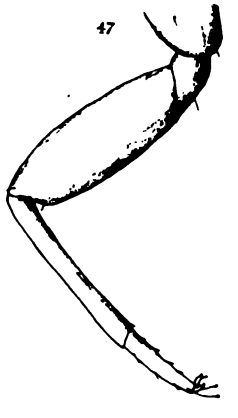
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## EXPLANATION OF PLATE XI.

*Pulvinaria oyamæ*, sp. nov.

Fig. 53. Female on twig.
Fig. 54. Antenna of female.
Fig. 55. Leg of female; 55*a*, claw.
Fig. 56. Marginal spines of female.

*Pulvinaria hazeæ.*

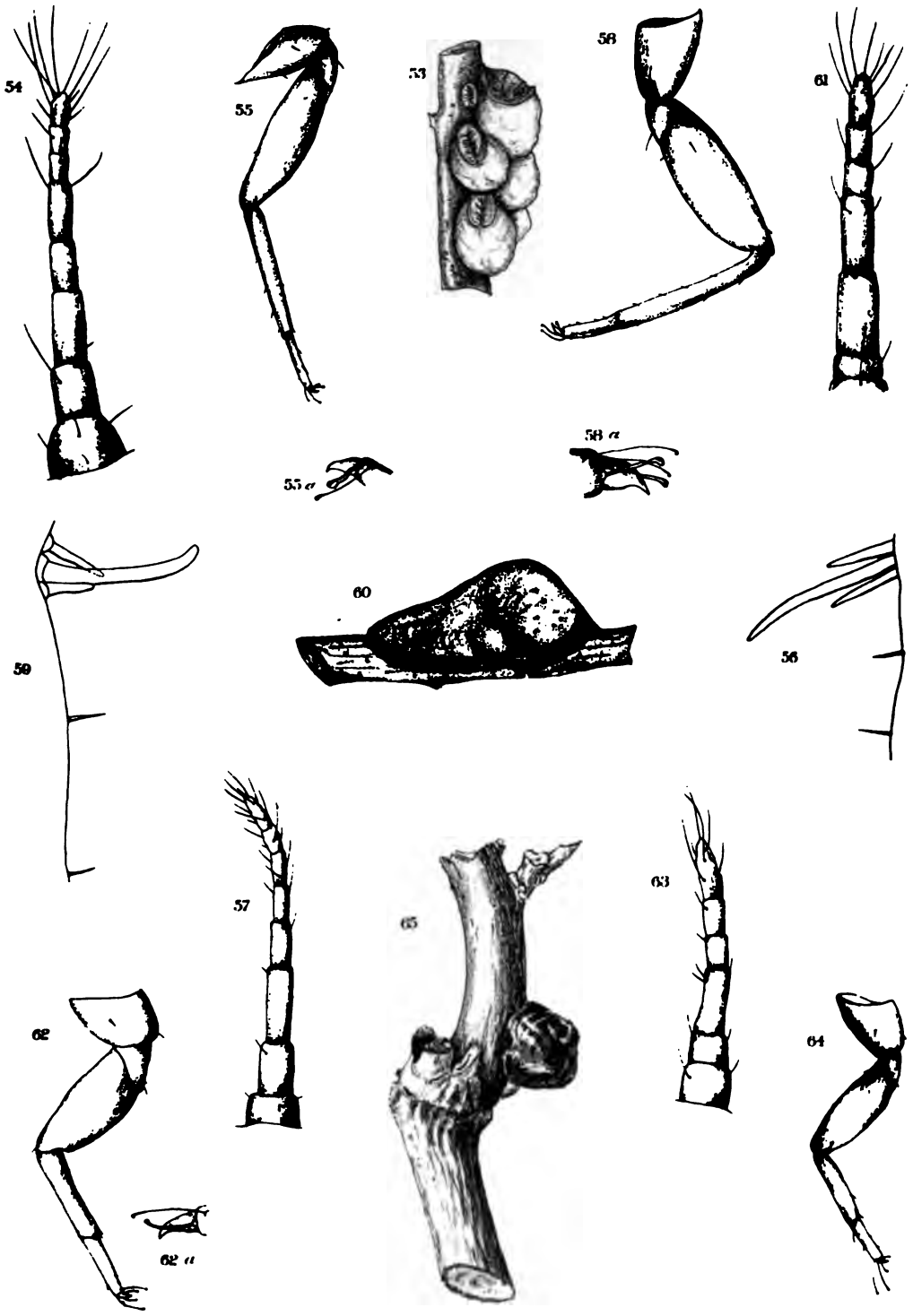
Fig. 57. Antenna of female.
Fig. 58. Leg of female; 58*a*, claw.
Fig. 59. Marginal spines of female.

*Lecanium takachihoi*, sp. nov.

Fig. 60. Female on a twig.
Fig. 61. Antenna of female.
Fig. 62. Leg of female; 62*a*, claw.
Fig. 63. Antenna of first larval stage
Fig. 64. Leg of first larval stage.

*Lecanium*, sp.

Fig. 65. Female on a twig.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55 a
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58 a
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62 a

## EXPLANATION OF PLATE XII.

*Aspidiotus cryptomeriæ*, sp. nov.

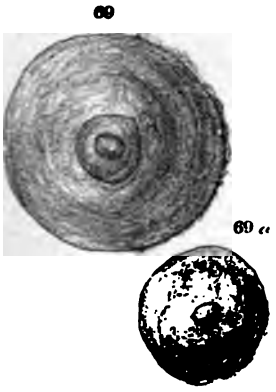
Fig. 66. Female scale; 66*a*, male scale.
Fig. 67. Female.
Fig. 68. Last abdominal segment of female.

*Aspidiotus jordani*, sp. nov.

Fig. 69. Female scale; 69*a*, male scale.
Fig. 70. Female.
Fig. 71. Last abdominal segment of female.

*Aspidiotus kelloggi*, sp. nov.

Fig. 72. Female scale; 72*a*, male scale.
Fig. 73. Female; 73*a*, antenna.
Fig. 74. Last abdominal segment of female.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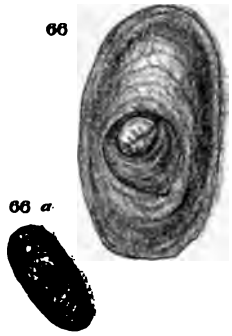
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66 a

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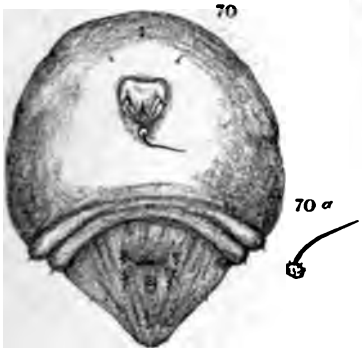
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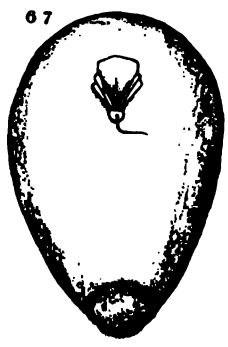
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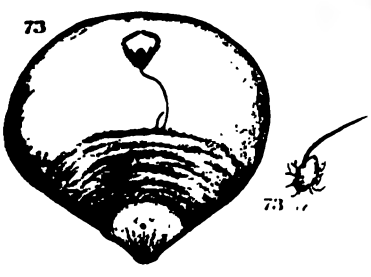
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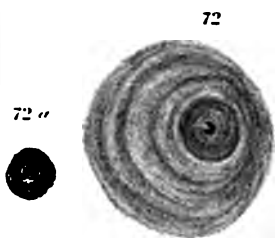
72
72 a

## EXPLANATION OF PLATE XIII.

*Leucaspis bambusæ*, sp. nov.

Fig. 75. Scales on a twig.
Fig. 76. Ventral aspect of female scale.
Fig. 77. Dorsal aspect of female scale.
Fig. 78. Female.
Fig. 79. Last abdominal segment of female.
Fig. 80. Antenna of first larval stage.
Fig. 81. Leg of first larval stage.

*Chionaspis hikosani*, sp. nov.

Fig. 82. Female scales.
Fig. 83. Last abdominal segment of female.

*Chionaspis colemani*, sp. nov.

Fig. 84. Last abdominal segment of female.

*Mytilaspis euryæ*, sp. nov.

Fig. 85. Scales on a leaf.
Fig. 86. Female scale.
Fig. 87. Female scale.
Fig. 88. Female.
Fig. 89. Last abdominal segment of female.

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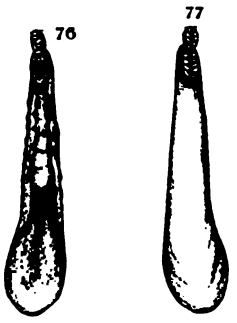
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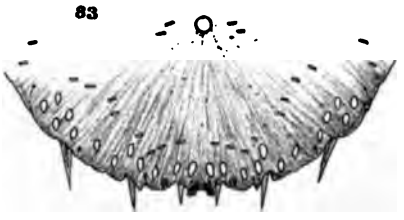
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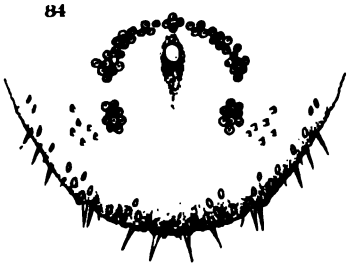
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PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

ZOOLOGY VOL. III, No. 3

# Some Observations on Ascorhiza occidentalis Fewkes, and Related Alcyonidia

BY

ALICE ROBERTSON

WITH ONE PLATE

*Issued March 14, 1902*

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1902

# Some Observations on Asoviniza occidentalis Fowkes and Related Alcyonidia

# SOME OBSERVATIONS ON ASCORHIZA OCCIDENTALIS FEWKES, AND RELATED ALCYONIDIA.

BY ALICE ROBERTSON.

PLATE XIV.

IN a paper entitled "New Invertebrata from the Coast of California," published in the Bulletin of the Essex Institute, Vol. XXI, 1889, Dr. J. Walter Fewkes describes a new and extremely interesting Bryozoan, *Ascorhiza occidentalis*, which had been dredged in the channel between Santa Barbara and Santa Cruz Island. The description, though full of interest, was admittedly deficient in some important points, and the writer was unable to arrive at definite conclusions in regard to the relationships of this curious Bryozoan. Since the publication of Dr. Fewkes' article in 1889, nothing farther had been learned of *Ascorhiza* until last summer, when several fine specimens were obtained at the Marine Biological Station of the University of California at San Pedro. A study of this new material has served to complete the description of this interesting species and to establish its relationships.

These specimens of *Ascorhiza* were dredged in forty-five fathoms off Santa Catalina Island, on the coast of California. This form is unique among the Bryozoa in having the major part of the colony elevated upon a segmented muscular stalk. The whole colony consists of a head, or capitulum, a stalk, and a basal portion by which it adheres to some foreign body. Fig. 1 represents such a colony, and shows the extremely flexible character of the stalk. Some of the specimens lacked the basal portion, the stem having evidently been broken off some distance above it. There is considerable variation in the height of the various specimens, but the relative heights of stalk and capitulum are about as five to one. Thus, in one perfect specimen, the stalk measured 10 mm., the head, 2 mm. In another, which had been torn from its substratum, the stalk is 23 mm. long,

the head 5 mm. In the other specimens about this proportion was maintained.

THE BASE.—According to the description given by Fewkes, the stalk of *Ascorhiza* was directly connected with the seaweed upon which he found it growing, i. e., without the intervention of a foot disc. The Catalina specimens, however, indicate that the colony rises from a thin incrusting layer composed of a number of zoœcia immersed in a gelatinous matrix (fig. 1, *b.*). A portion of the stalk (*stk.*) with a part of the base (*b.*) very much magnified is represented in fig. 2. The outlines of the partially immersed zoœcia (*z.*) are plainly discernible. Although no polypides can be distinguished, the zoœcia being filled with granular material, and being partially covered with debris, the septa are well marked, and the shape of the zoœcia corresponds with those of the capitulum (figs. 2 and 3). Since the specimens were disconnected when they were studied, it is not known whether or not the incrusting layer is continuous from stalk to stalk. On the evidence of one collector the basal portion was not continuous in those specimens which he obtained, but the colonies grew quite far apart on the surface of a stone. A second lot was found, however, by another collector, all the specimens of which were growing close together on a broken shell. None of the youngest stages were obtained, which would show the process by which *Ascorhiza* passes from a horizontal to an upright position. But it seems extremely probable that when the incrusting portion is young its zoœcia contain active polypides which continue to function until those of the head are advanced enough to carry on the work of nutrition.

THE STALK arises from the basal portion, and consists of an external layer, or cuticle, and an internal layer of muscle plates, or "blocks," as they are designated by Fewkes. Fig. 2 shows that the ectocyst of the stalk is a direct continuation of that of the base. This outer layer, or cuticle, is tough and resistant. It is very transparent, and is deeply constricted at regular intervals, the constrictions marking more or less perfectly the muscular segmentation of the stalk.

Viewed in optical section, the muscular plates are seen passing from the base and extending through the stem into the head (fig. 1). At the proximal end of the stalk, the muscle plates are crowded together somewhat irregularly, but farther up they become more regularly disposed in rings or segments. Just above the junction of the head and stalk the irregular arrangement of the plates is very marked. The reason for this becomes evident when it is found that new plates are formed by a process of intercalation. Each originates as a minute bud surrounded by a delicate ectocyst (fig. 3, *m. b.*), pushing its way among its neighbors and shoving them away from all sides of it. Each muscle bud takes what shape it may conformably with its surroundings. At first it is rounded or triangular; then it becomes oblong, with its long axis at right angles to the axis of the stem. As growth proceeds, it finally becomes longer than broad, and takes its place in a definite segment. The muscle plates extend in a single layer around the stem, and are arranged much as the bricks in a wall. Each is lined with a layer of epithelial cells, within which there extends a layer of muscle fibres from the upper to the lower edge of the plate. The boundaries of the muscle plates are as distinct as those between the zoœcia of the head, or base; and in no case do the muscle fibres extend from one muscle plate to another. In cross-section (fig. 4), the stalk is seen to possess, for the most part, only a single layer of these muscular structures. They surround a central cavity or lumen (*l.*), which is continuous with a cavity in the head.

The number of fibres in a muscle plate seems to vary, the larger part of the interior being occupied, in some instances, by mesodermal cells. In two instances, a number of sections in a series showed a rounded greenish body (*g. b.*), reminding one of the remains of a degenerated polypide. It was remarked above that the stalk is, for the most part, one-layered. There is evidence, however, that the muscle plates overlap to a certain extent, so that at intervals there will appear in cross-section the lower part of an upper plate lying inside of the boundary of a lower plate.

Fig. 5 reveals such a condition, in which the muscle plate *my*¹. is at a higher level in the stalk than *my*²., and is gradually disappearing, while *my*². is coming in to take its place. For short distances, at intervals, then, the stalk is double-layered. The muscle plates are imbedded in a homogeneous matrix which possesses no cellular structure whatever.

THE HEAD.—If the whole of the expanded portion constitutes the head, or capitulum, then it must be said to consist of two apparently distinct elements—muscle plates and zoœcia.

The lower portion of the head is the budding region for the muscle plates (fig. 1, *m. b.*) and in their earliest stage a muscle plate cannot be distinguished from a zoœcium and its contained polypide. Fig. 3 represents this transitional region, where both polypides (*p. b.*) and plates (*m. p.*) are forming. The young muscle plates are characterized by a scattering of the pink-staining cells throughout the containing ectocyst; whereas in an ordinary zoœcium the cells destined to become a polypide are aggregated near the center, and soon bud out the tentacles and other organs. The ectocyst, too, early acquires the zoœcial aperture through which the tentacles are protruded (fig. 3, *a.*).

The head is oval in form, and consists for the most part of zoœcia imbedded in a gelatinous matrix, similar to that of the stalk, but much thinner. The upper portion of a zoœcium is visible on the surface. In the retracted state, the orifice and a portion of the tentacle sheath only can be seen. The remainder of each zoœcium containing the major portion of the polypide extends inward toward the central cavity of the head. The zoœcia are thus crowded together and overlap to a certain extent, to a greater degree, but in much the same way as the muscle plates of the stalk.

Polypides in every state of development are found all over the upper portion of the capitulum. Fewkes observes that the more developed polypides lie at the distal pole of the capitulum. This is not confirmed in the present instance, for young polypide buds are found pushing their way between adult zoœcia at the distal pole quite as commonly as below that region, while the lower pole is entirely

occupied by the muscle plate buds. Fig. 6 is a sketch of a single polypide dissected out from the head. The general shape is that of an ectoproct. The circle of tentacles does not include the anal aperture, but surrounds the mouth-opening only, to the number of sixteen or eighteen. The mouth opens into a pharynx lined by large granular cells; this into a relatively long œsophagus, a sac-like stomach, a short intestine, and rectum. Upon dissection, certain yellowish bodies which appeared on the surface of the head proved to be ciliated larvæ, two of which occupied a zoœcium. Are these the "yellow pigment spots" to which Fewkes refers?

RELATIONSHIPS.—From the data which a study of the polypide affords, there is no difficulty in placing *Ascorhiza* with the ectoproctous Bryozoa. A similar study of the zoœcia and their mode of growth as surely places it in the subclass Ctenostomata, and as Fewkes suggests, somewhere near the genus *Alcyonidium*. Regarding the capitulum by itself, it would be hard to distinguish it from a very minute colony of *Alcyonidium gelatinosum*, or of *A. mytili* whose zoœcia had become much crushed or crowded together. Fig. 7 is a sketch of a tentacle sheath as seen from the inside of the capitulum. It is typically Ctenostomatous in the infolding of the tube, its closure by fine bristles (*br.*), and by the muscles which form the so-called diaphragm (*dia.*).

In his discussion of the relationships of *Ascorhiza*, Dr. Fewkes seems to consider that the possession of a stalk relates it to the entoprocts, especially to *Urnatella*, and perhaps to *Ascopodaria*. He suggests that it may constitute a connecting link between the entoprocts and ectoprocts and thus assist in settling the disputed question of the relationship of these two groups of Bryozoa. From the point of view of the present writer, such a relationship does not exist. The stalked condition, although hitherto unknown in the family Alcyonidiidæ, does not constitute a morphological barrier to membership in this family. As will be shown later, at least one other stalked form, belonging to the genus *Alcyonidium*, occurs on the Pacific Coast.

The method of formation of the stalk is clearly only another illustration of the phenomenon of polymorphism so frequently met with among the Bryozoa. The stalk of *Ascorhiza* consists of transformed zoœcia as unmistakably as do the ovicells of *Crisia* or the avicularia of *Bugula*. The evidence for the homology of zoœcia and muscle plates lies first in their similar origin. Each arises as a small bud within the gelatinous matrix, and in the transitional region represented in fig. 3, the one cannot be distinguished from the other in the earliest stages. Farther evidence is afforded by the cross-section (fig. 5), in which the mode of growth of both muscle plates and zoœcia is shown to be similar in the adult stage, that is, in the older parts of the stalk there is a certain amount of overlapping just as there is in the zoœcia of the capitulum or of the base. Furthermore, the green body represented in fig. 4, *g. b.*, is extremely suggestive of the histolyzed remains of a polypide, such as are found in the capitulum. The muscle plates are regarded, then, as highly differentiated zoœcia, whose polypide bud has been transformed into muscle fibres. They form distinct muscular elements of the Ascorhizan colony, and may be termed *myœcia*, whose function it is to elevate the colony and to afford it a means of movement.

Although the stalked condition shown in *Ascorhiza* is a unique feature in the family Alcyonidiidæ, yet an approximation to it is found among some of the erect *Alcyonidia*. If the lower portion of the ordinary *Alcyonidium gelatinosum* be examined, it will be found to be more or less modified. In a small cylindrical colony about four inches high and half an inch in diameter, the lower zoœcia for the distance of an inch from the base have become somewhat changed, or rather, somewhat less gelatinous, and may be regarded as supporting structures.

During the course of the Fur Seal Investigations in Alaska in 1896–97, under the direction of Dr. David Starr Jordan, several specimens of Bryozoa were collected at the Pribilof Islands which show an approach to the stalked condition of *Ascorhiza*. They resemble pedunculated

simple Ascidians, and were probably collected for such. Two regions are well defined—an upper, expanded portion containing actively functioning polypides, and a lower, stem-like portion, whose function is mainly supporting. One of these colonies is represented in fig. 8. It rests on a small disk (*d.*) from which there grows a solid stalk-like portion (*ped.*), in this instance occupying about a third of the whole height of the colony. The remaining two-thirds consist of the nutritive and reproductive animals whose zoœcia form a single-layered, gelatinous, bag-like structure. In other specimens the stalk is shorter and more distinctly differentiated. Fig. 9 represents such a form.

In cross-section the stalk is circular, and consists of a solid mass of zoœcia radially arranged, many of which contain functioning polypides. The cuticle is brown and somewhat thickened, and acquires a few wrinkles. No structures corresponding to the myœcia of *Ascorhiza* occur, the zoœcia of the stalk never losing their primitive character. The expanded upper portion varies in height from one to two inches. The surface is smooth, the zoœcia are immersed, forming usually a single-layered bag, the interior of which is filled with a loose tissue.

The form and arrangement of the zoœcia connects this species with *Alcyonidium*, while the possession of a stalk relates it to *Ascorhiza*. It lacks, however, an important character of the Ascorhizan stalk. There are not only no muscular elements in the stalk, but in the head there is no region where the distinctively peduncular elements are produced, such as *Ascorhiza* possesses.

The possession of a peduncle distinguishes this species from other known *Alcyonidia*, and seems to be a constant character. It will serve, therefore, as the basis for a new species, *Alcyonidium pedunculatum*, which will occupy a position intermediate between other erect *Alcyonidia* and *Ascorhiza*. In order to receive these two new members, viz., *Ascorhiza occidentalis* and *Alcyonidium pedunculatum*, the definition both of the family Alcyonidiidæ, and of the genus *Alcyonidium* will have to be broadened somewhat. Accepting the definition of the family given by Hincks in

British Marine Polyzoa, it will only be necessary to expand it and to insert the phrase, "or zoarium, in whole or in part, elevated upon a stalk, or a short peduncle," thus:—

## Family ALCYONIDIIDÆ.

Zoœcia more or less closely united, immersed in an expanded and adherent gelatinous crust, or forming an erect cylindrical or compressed zoarium; or zoarium, in whole or in part, elevated upon a stalk or short peduncle; orifice closed by the mere invagination of the tentacular sheath; not protected by external labia.

### Genus Alcyonidium *Lamouroux.*

Zoarium immersed or subimmersed; the orifices simple, papilliform. Zoarium gelatinous or argillaceous, either crustaceous, erect, or pedunculated.

### Alcyonidium pedunculatum, sp. nov.

Zoarium composed of a more or less compressed, bag-like portion forming the head, or capitulum, and a short stalk, or peduncle. Capitulum single-layered for the most part, surface smooth, interior filled with a web-like tissue. Peduncle consisting of a solid mass of zoœcia more or less radially arranged, and growing from a small disk, by which it is attached to the substratum.

### Genus Ascorhiza *Fewkes.*

### Ascorhiza occidentalis *Fewkes.*

Zoarium consisting of an oval, single-layered capitulum, borne on the summit of a segmented muscular stalk arising from an incrusting base. Capitulum consisting for the most part of actively functioning zoœcia, the lower portion, however, constituting the budding region for the structures which form the stalk. Surface smooth, zoœcia packed close together. Stalk composed of muscular plates or myœcia, homologous with zoœcia, entirely immersed in a gelatinous matrix. Myœcia radially arranged in irregular rings, or segments, around a central cavity continuous with that in the head, each containing a number of muscle fibres extending longitudinally from one side of the myœcium to the other. Surface of stalk marked by constrictions corresponding somewhat imperfectly to the myœcial segmentation. Stalk directly continuous with the base, which consists of a single layer of zoœcia forming the means of attachment to the substratum.

University of California,
Berkeley, California,
October 19, 1901.

## ABBREVIATIONS USED IN THE FIGURES.

*a.*—aperture.
*b.*—base.
*br.*—bristles.
*cap.*—capitulum.
*d.*—disc.
*dia.*—diaphragm.
*g. b.*—green body.
*int.*—intestine.
*l.*—lumen.
*m. b.*—muscle bud.
*m. p.*—muscle plate.
*my.*—mycecia.
*œ.*—œsophagus.
*p. b.*—polypide bud.
*ped.*—peduncle.
*ph.*—pharynx.
*r.*—rectum.
*stk.*—stalk.
*st.*—stomach.
*tent.*—tentacles.
*trans. re.*—transitional region.
*z.*—zoœcia.
*z. re.*—zoœcial region.

## EXPLANATION OF PLATE XIV.

*Fig. 1.* *Acanthina accidentalis* Pergens. A single stalk containing basal portion (*b.*) and capitulum (*cap.*). Lower portion of latter constitutes the region for the formation of the muscle plates (*m. b.*) of the stalk (*stk.*).

*Fig. 2.* Represents the basal portion (*b.*) enlarged, together with the first three segments of the stalk (*stk.*). The muscle plates, or myocia (*my.*), crowded irregularly into the stalk.

*Fig. 3.* Part of the transitional region (*trans. rg.*) in the lower portion of a capitulum, with a small portion of the zooecial part (*z. rg.*) above, and of the stalk (*stk.*) below. The zooecial region represents the adult zooecia with the intercalated polypide buds (*p. b.*). Directly beneath, muscle plate buds (*m. b.*) and polypide buds (*p. b.*) are seen developing side by side. Below this, the muscle plates (*m. p.*) are recognized by the growth of the muscle fibers, while lower still, at the distal end of the stalk (*stk.*), the adult muscle plates (*m. p.*) are more regularly arranged.

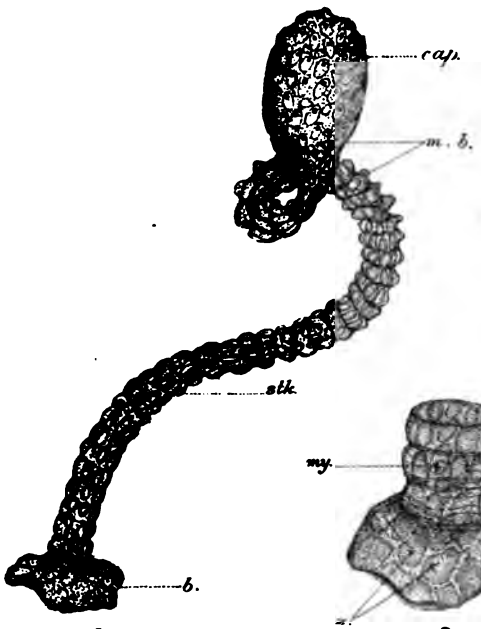
*Fig. 4.* Portion of the cross-section of a stalk, showing the central lumen (*l.*) and four myocecia (*my.*), one of which contains a greenish rounded body (*g. b.*)

*Fig. 5.* Portion of the cross-section of the same stalk, showing lumen (*l.*) also the overlapping of the myocecia, $my^1$. disappearing, while $my^2$. is coming in to take its place.

*Fig. 6.* Sketch of a polypide to show the relation of the organs.

*Fig. 7.* Sketch of a tentacle sheath showing its ctenostomatous characters.

*Figs. 8 and 9.* *Alcyonidium pedunculatum*, sp. nov. A complete colony, showing the disc (*d.*) by which it is attached, the peduncle (*ped.*), and the large ascidian-like capitulum (*cap.*).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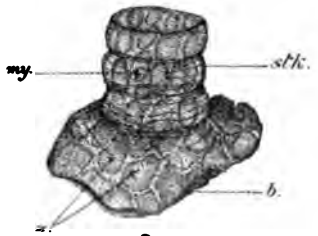
1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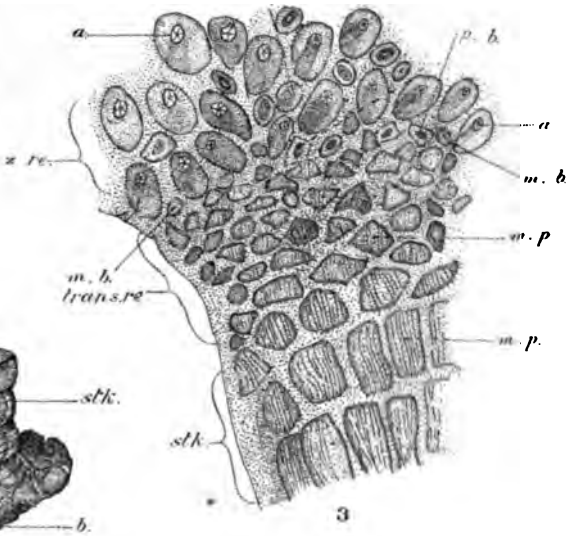
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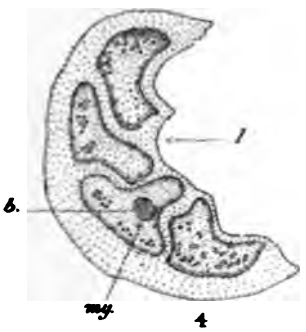
3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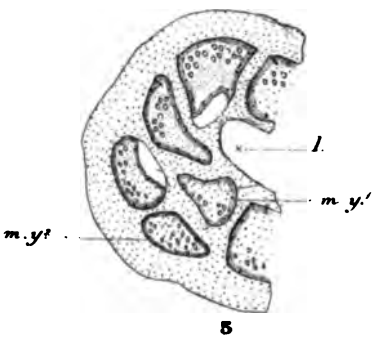
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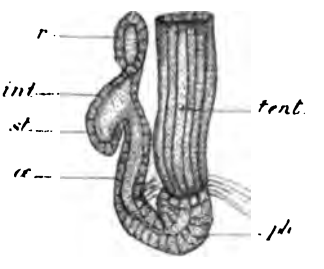
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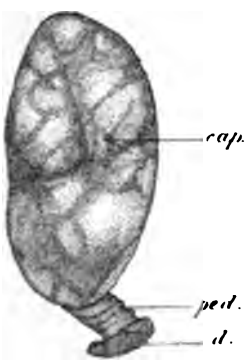
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9

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7

cap.
ped.
d.

8

PROCEEDINGS

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# The Anatomy of Epidella squamula, sp. nov.

BY

HAROLD HEATH

*Assistant Professor of Zoology, Leland Stanford Jr. University*

WITH TWO PLATES

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# THE ANATOMY OF EPIDELLA SQUAMULA SP. NOV.

BY HAROLD HEATH

*Assistant Professor of Zoology, Leland Stanford Jr. University.*

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## I. INTRODUCTION.

IN common with the other members of the genus *Epidella*, this new species is an ectoparasite frequently occurring on the Bastard Halibut (*Paralichthys californicus*), and far less often upon various species of Rock Cod (*Sebastodes*) in the waters of Monterey Bay and vicinity. Their usual point of attachment is the under surface of the fish, rarely the gill-cavity, where they congregate in numbers ranging from one to more than a hundred, according to the size of the host. In form they are thin and leaf-like, unpigmented, but of a light yellow color owing to the yolk-glands which show through the transparent tissues, a characteristic which also enables one to observe in living specimens the various organs of the body and many of the

phenomena connected with the egg-laying process. The numerous individuals taken measure in a preserved state from 3.5 millimeters by 1.5 millimeters to 18 millimeters by 10 millimeters. All were sexually mature.

It is an interesting fact that the largest individuals are found only on large-sized fishes, and that to a certain extent the size of the parasite is proportional to the size of the host. Just what the governing factors are in this case it is difficult to imagine. It can scarcely be attributed to an inability to retain a foothold when the scales are relatively large; and it is also unlikely that the host and parasite are the same age, and that, for example, medium sized trematodes will acquire a large size months or years hence, when the fish is fully grown.

## II. EXTERNAL CHARACTERS.

The general surface of the body appears smooth, but in reality is beset with exceedingly minute and short projections of the cuticle. Other cuticular elevations of much larger size occur on the under surface of the posterior sucker, especially on its posterior half, where they have the form of low rounded knobs. In the lateral portions these are arranged in rows, but in the median area of the posterior half they are irregularly disposed. On the ventral surface of the body, near the anterior end, is the mouth-opening, in front of which are two sucking discs. On the left side about the level of the mouth is the common opening of the male and female reproductive systems. The dorsal surface is devoid of any important obvious structures except the excretory pores, two in number, which are situated on either side of the median line near the anterior end of the body (fig. 11, *e*).

The anterior adhesive organs (fig. 11, *a*) are elliptical in form, with their margins but slightly elevated, and accordingly the disc area contains a relatively shallow depression. Special radial and circular muscles are apparently absent; a marginal membrane (Randmembran) is also wanting, and

in all essential respects these organs appear to resemble the sucking pits (Sauggruben) of many trematodes, especially *E. hippoglossii* as figured by van Beneden (1861). The cells of which they are composed are chiefly columnar, and appear to be devoid of any cuticle upon their free extremities. Their opposite ends frequently become produced into from one to three processes, from which delicate fibers, probably nerve, extend far into the tissues of the body. Muscle fibers may be detected among the bases of these cells, and also the long and slender ducts of a few dorsally situated unicellular glands which apparently open to the surface. The muscle fibers in every case appear to be merely the termination of the great bands which are located immediately beneath the cuticle on the dorsal and ventral surfaces of the body. In specimens treated with methylin blue these somatic muscles, transverse, oblique, and longitudinal, become clearly differentiated, and are then seen to split up into a number of delicate branches upon approaching the margins of the body. This also occurs in the region of the anterior sucking discs, and the latter appear to be controlled wholly by these small fibers, and to lack definite muscles of their own.

The anterior sucking discs are brought into use as adhesive organs chiefly when the animal is changing its position and the posterior disc is unattached. Under such circumstances they are sufficient for this almost instantaneous shifting, but compared with the great posterior sucker their power of adhesion is relatively weak. It appears probable, judging from their abundant nerve supply, that they function principally as sense organs, as Braun (1887) suggested several years ago. When disturbed, some individuals may be seen to wave the forward part of the body about, and to touch it lightly to the host as if in search of a more suitable place for attachment, a movement common to many leeches. As in the latter, undulatory movements of the body also occur, while both extremities of the animal are attached, which probably aid in the process of respiration.

In *E. squamula* the posterior sucking disc (fig. 1) is more

than half the width of the body, and its various hooks and highly developed musculature render it a powerful organ of adhesion. It is attached to the posterior end of the body by a comparatively slender and short pedicel, whose downward flexure brings the disc to a ventral position where it is partially covered by the body. Three pairs of hooks of different sizes are imbedded in its substance, and protrude upon its under surface. Of these, one pair is relatively very small and not a constant feature in the different species of this genus. Van Beneden (1861) has figured and described it in *E. hippoglossii*, and von Linstow (1889) for *E. (Phylline) hendorffii*, while it is absent in *E. bumpusii*, judging from Linton's figures and account (1899). Of the remaining pairs of hooks the anterior are the shorter, and are directed forward and outward. The hooks of the third and largest pair, arcuate in form, extend from about the center of the disc to its posterior border, where they emerge with ventrally directed tips. The muscles producing their divergence and approximation are attached to a ridge extending diagonally along their ventral surface. The base of each of the four largest spines is invariably enveloped in one or two large branched cells, and processes from neighboring parenchyma cells also extend to their surface, and apparently spread out to form a thin enveloping sheet, which stains sharply in iron-hæmatoxylin.

The muscle fibers passing from the body through the central part of the pedicel radiate in all directions toward the periphery of the disc. Many of those extending along the more external portions of the stalk follow a similar course, but a considerable number from its right side spread out into the left side of the disc, and those from the left cross over to the right. Circular muscles are also present, especially toward the outer margin of the sucker, and multitudes of fibers penetrate it in a dorsoventral direction. To each spine is attached one or many muscles, some of which are represented in fig. 9. The marginal membrane has its supply of radial and circular fibers; and numerous smaller bands, too numerous and complicated to

allow of description, complete the musculature of the posterior sucking disc. The cuticular elevations on the under side of the sucker appear to sink into the corrugations of the scales of the host, and thus prevent the sliding of the parasite on the otherwise slippery surface.

## III. THE DIGESTIVE SYSTEM.

As in other ectoparasites, the alimentary canal consists of three elements, the pharynx, œsophagus, and intestine. In *E. squamula* the first of these commences with the crescentic mouth-opening situated on the ventral surface close to the anterior end of the animal. In life the lips are possessed of considerable mobility, but in preserved specimens definite lip muscles are found to be few in number, and anything of the nature of chitinous jaws or cuticular modifications of other kinds is absent. The mouth-cavity likewise is but little developed, and passes insensibly into the space within the pharyngeal sheath whose boundaries are represented in fig. 17.

As the figures indicate, the pharynx is more or less globular in form, and is composed of several sets of cells of widely different character. Those composing its free extremity (fig. 17, *l*) number from eight to eleven, and present a spongy appearance except in the immediate vicinity of the nucleus where the protoplasm becomes more compact. Imbedded in these larger cells are a few relatively small nuclei belonging apparently to interstitial cells, but owing to the lack of definite characters and to the indistinctness of the boundaries between the cells of this region, it becomes impossible to determine their exact nature. Immediately below the cuticle which covers the free extremities of these cells is a layer of circular muscles whose contraction in coöperation with similar muscles in other parts of the pharynx results in protracting the latter a short distance through the mouth-opening.

The cells of the second type (fig. 17, *f*) are situated immediately behind those just described, and are at once

distinguished by their free extremities, which project into the pharyngeal cavity in the form of conical papillæ. Their number varies according to the size of the individual, and as far as could be determined ranges from about twenty-five to fifty. In fully grown individuals, where these cells are correspondingly large, they may readily be seen to conform to the type of gland-cell which has been termed "diakrinous." The major portion of each consists of finely granular protoplasm, in which is imbedded a sharply defined spherical nucleus, often with densely aggregated chromatin and one or two comparatively large vacuoles (fig. 6). Toward the free end of the cell the nature of the protoplasm changes, losing its granular character and affinity for stains and assuming a striated appearance. This latter feature is due to a large number of intracellular canals which connect on the one hand with the glandular portion of the cell, and on the other with a minute reservoir. The latter is often filled with a darkly staining secretion, and may readily be followed to the cuticle, where it opens by a minute funnel-shaped aperture.

Other monogenetic trematodes have been described as possessing somewhat similar papillæ in the anterior half of the pharynx; but in some cases, at least, they are said to afford an outlet for the ducts from the cells (Körnerdrüsen) in the posterior half of the pharynx. The ducts from these last-named elements often extend forward for a considerable distance, but in *E. squamula* I have never seen them invade the territory of the diakrinous glands.

The second division of the pharynx, devoid of papillæ, consists primarily of a number of gland cells (fig. 17, *k*) which probably correspond to the so called pharyngeal glands (Pharyngealdrüsen or Körnerdrüsen) of a number of other monogenetic trematodes. In most cases the protoplasm is compact, the nucleus dense and darkly staining, and the ducts which lead to the exterior are short and usually ill-defined. Among the cells of this nature are often one or more of a spongy appearance with diffuse nuclei, characters which appear to be due to the recent

discharge of their secretion (fig 17, *k*). In addition to these, there are a small number of gland cells containing relatively coarse granules which remain unstained when treated with iron-hæmatoxylin. In most cases their ducts are likewise difficult to determine, but when filled with secretion they may be traced directly to the pharyngeal cavity (fig. 17, *r*).

Ganglion cells also occur in various positions in the pharynx and the terminal cells of branches of the excretory system. Circular and radial muscles are also well developed, and occupy positions adequately shown in fig. 17. Among these elements of the pharynx are a few relatively small spherical nuclei whose exact nature it is difficult to determine. In macerated specimens they appear to belong to slender columnar cells which occupy interstices between the gland cells, and are apparently supporting cells.

The œsophagus, with which the rounded posterior extremity of the pharynx connects, is relatively very short and insignificant, serving chiefly as a point of entrance for the salivary glands. The latter consist of a multitude of distinct cells arranged in two groups (fig. 12, *s*), each of which extends in a rough way from the hinder border of the pharynx, the prostate gland, the oötype, and the anterior end of the reservoir of the excretory system, to a line some distance within and parallel to the margin of the body. Each cell is pear-shaped in outline, with its pointed end continuous, with a slender duct which leads, usually by a fairly direct route, to its separate outlet into the œsophagus. Some of the cells contain clear vesicular nuclei, while in others they are relatively small and dense. In almost every case the cytoplasm is loaded with a coarse granular secretion, which has a great affinity for logwood dyes.

The intestine of *E. squamula* is of the usual bifurcated type in which the two main branches are connected posteriorly by a commissure. The main system gives rise to a considerable number of minor branches, which after forking repeatedly end blindly among the tissues of the body. Along the median line several of the smaller twigs appear

to unite to form commissures, but sections and injections[1] clearly show that such is not the case.

The cells lining the intestine are cubical or rectangular in outline in individuals which have been kept for some time in captivity. In an active condition their free borders become irregular and amœboid in appearance, and in very many cases seem to be in the act of liberating portions of their substance. This makes it altogether possible that they are zymogenic, producing some ferment which acts upon the food; but there is no definite proof that such is actually the case.

The food of this trematode consists of the slime from the surface of the body of the host. In rare cases this in an apparently unchanged condition may fill the cavity of the intestine, but in most cases it rapidly dissolves after its entrance into the body. In living individuals the resulting watery food substances, containing numerous granules, may be seen to circulate backward and forward owing to the periodical dilation and contraction of the intestinal walls. The indigestible substances, chalky white in appearance, and somewhat viscous, gradually accumulate in the tract immediately behind the œsophagus, and are finally violently expelled.

## IV. The Male Reproductive System.

In *Epidella squamula*, as in all monogenetic trematodes, the male and female reproductive organs occur in the same individual. The testes (fig. 11, *t*), two in number, are more or less round disc-shaped bodies situated about the middle of the animal, equidistant from the dorsal and ventral surfaces. Each is surrounded by a feltwork of delicate fibers of connective tissue which extend to it from the neighboring parenchyma, and is penetrated by several bundles of dorsoventral muscle fibers which pierce the sheath.

[1] Injections of the alimentary canal, and often of many of the branches of the excretory system, may be made by transferring the specimens from absolute alcohol directly into a clearing agent, such as oil of cedar or cloves. Owing to the inequality of the osmotic currents, these tubes under favorable circumstances become completely filled with air.

In the crypts thus formed the sperm occur in all stages of development, which appears to closely follow the plan most accurately determined by Goto (1895), in *Microcotyl caudata*.

The ducts leading from the testis (vasa efferentia), and often funnel-shaped for a short distance, unite in the median line with the vas deferens, which passes forward to the right of the ovary, and after a tortuous course penetrates the wall of the reservoir in which the secretion of the prostate glands is stored. Traversing this, it finally opens into the cavity of the penis near its base. Throughout its entire extent it is invariably filled with sperm, and is also sharply separated from the adjoining tissues by a sheath of apparently the same character as that surrounding the testis. On the inside of this investing coat in the terminal third of the vas deferens is a series of ten or twelve cells, clear as crystal in life, whose position is more accurately indicated in fig. 13, *x*. In the region of the large spherical nucleus each cell projects far into the lumen of the duct (fig. 4), but from this point gradually becomes thinner as it extends around the wall or to the point of contact with neighboring cells.

Goto (1895) has discovered similar cells in the vas deferens of *Microcotyl chiri* and *M. sciænæ*, and considers them the remnants of the epithelial cells of which the vas deferens was originally formed. Nothing short of a study of the development of these organs will settle such a question, but there is no doubt that if they are remnants they nevertheless serve some function in the mature worm. The protoplasm of which they are composed is finely granular, staining uniformly, and while there are some reasons for considering them to be gland cells, there is nothing which definitely determines their nature.

Another set of problematical cells is situated behind each testis in the angle which one makes with the other (figs. 7, 11), but whether they are associated in any way with the reproductive system it is impossible to state. They are always four in number, perfectly transparent in living specimens, and are composed of finely granular protoplasm, usually vacuolated except in the immediate vicinity of the

nuclei. The latter are sharply defined, relatively large, and number from three to seven in each cell, or group, if they be considered syncytia. In some cases these cells are of perfectly sharp contour, but in other examples the anterior extremities are drawn out to form a stem. Whether this is the commencement of a duct has not been decided, since it rapidly vanishes into the neighboring connective tissue and yolk-glands.

The penis is attached to the outer extremity of a two-layered sac which is invariably filled with the secretion from the prostate glands. Goto recognized this latter substance, and states that "what von Linstow (1889) calls the 'Samenblase' in *Phylline hindorffii*, and P. J. van Beneden (1861) the 'vesicule seminale,' situated outside the penis in *E. hippoglossii*, is undoubtedly the prostate gland." Judging from *E. squamula*, this latter statement is questionable. These variously named vesicles are in all probability reservoirs for storing up the prostate secretion, but the latter is developed in cells located some distance from this point.

In living specimens the secretion of the prostate glands in the reservoirs is snowy white, and appears in marked contrast to the surrounding tissues. Two delicate cords of the same character (figs. 12, 13 *p*) may also be seen extending from the innermost enlargement of the prostate reservoir, and may be traced backward along the sides of the ovary. Here each splits up into a number of branches which pass to the sides of the testes or between them, and become lost beyond this point in the body parenchyma. In sections these fibers are found to be made up of a large number of delicate ducts which open into the prostate reservoir on its ventral surface, and on the other hand, to connect with cells in the vicinity of the testes.

In the region bounded anteriorly by the testes, posteriorly by the margin of the body and the pedicel, and laterally by the inner pair of longitudinal nerve cords, are a large number of gland cells. Many of these communicate with the posterior sucker (fig. 12), while others connect with

ducts leading to the prostate reservoirs. All these cells, similar in form, react in essentially the same way when treated with different reagents, and although they undoubtedly belong to various categories it is impossible to differentiate them. A considerable number immediately behind the testes lead to the prostate vesicles, and many others located farther backward appear to pursue the same course. As noted above, the ducts follow different routes until they arrive in the neighborhood of the ovary, but from this point they become closely associated, and pursuing a somewhat wavy course open into the prostate reservoirs.

The walls of the latter are composed of a felted mass of connective tissue fibers which at many points may be seen to pass off into the surrounding parenchyma. A few muscle fibers without any apparent definite arrangement lie in the substance of this sheath. Ganglion cells are also visible on its outer surface, and the terminal cells of the excretory system are frequently noted in preserved and living specimens. Within the vesicle a considerable number of muscle and connective tissue bands extend from the anterior lobe of the reservoir into the posterior, where they radiate and attach to its walls.

The penis (figs. 11, 13) is a hollow, conical organ lying almost wholly in the genital atrium. It is totally devoid of any chitinous modifications, and is accordingly a comparatively weak structure. The spongy connective tissue of which it is composed is apparently directly continuous with the closely matted fibers forming the walls of the prostate reservoirs.

The muscles of the penis consist of the outer and inner sets of circular muscles and the longitudinal bands. The first of these is well developed, and occupies a position immediately beneath the limiting membrane. Beneath these lie the irregularly disposed longitudinal fibers, which are usually continuous with the somatic muscles or with those imbedded in the walls of the prostate reservoir. On the side of the penis which is traversed by the vas deferens a comparatively few longitudinal fibers extend within the reservoir and become attached to its walls.

During life the penis is often moved backward and forward within the genital atrium, or becoming relatively slender, its tip may be protruded through the external opening. In captivity this is not a frequent occurrence, but that it does occur is an undoubted fact. In rarer cases the fibers traversing the prostate reservoirs contract, and thus compressed the prostate secretion is forced through the penis, and in some cases out of the opening of the genital atrium. Here it remains undissolved, showing furrows formed by wrinkles in the walls of the genital atrium and giving evidence of being a thick and viscous substance.

The vas deferens enters the walls of the prostate reservoir at the constriction between its two lobes (fig. 13). From here it passes forward imbedded in the thick wall of the same side, and opens into the lumen of the penis at the summit of a minute papilla visible in living specimens. This included section is usually distended with sperm, and is probably homologous with the ductus ejaculatorius in other species of trematodes.

## V. The Female Reproductive System.

The ovary, double convex in form, is situated in the median line a short distance anterior to the testes (fig. 11, 13, *ov.*). The enclosing sheath in all essential respects resembles that of the testes. Immediately beneath this the germ cells are usually minute, and constitute a growth zone from which the developing ova migrate, increasing in size as they pass inward. There are also from one to upwards of a dozen small groups of cells scattered throughout the ovary. These groups consist of cells of various sizes, some of which may rarely be found to be in the process of division. The fully formed ova are characterized by a well defined cell membrane, the absence of yolk, a large nucleus, and especially large nucleolus.

Outside of the egg-laying period, the oviduct, consisting of spongy protoplasm containing numerous nuclei but devoid of definite cell boundaries, may readily be traced from about the center of the ovary to a point on its anterior

surface somewhat to the right of the median line. Here it makes its exit, and after one or two slight bends unites with the yolk-duct, and passes on to the oötype or egg-mould (fig. 13, *o*). During the reproductive period the ripe eggs pass from the ovary and take up their position within this first section of the duct, which accordingly becomes much distended, and closely united with its sheath. The free portion, outside of the ovary, remains unchanged, and serves to convey the eggs one by one into the egg-mould.

The yolk-glands (fig. 11) are scattered widely over the body, occupying all the available space between the branches of the alimentary canal, excretory system, and the various organs of the reproductive system. In each follicle are cells in all stages of the yolk-secreting process; at first containing relatively few refractive granules imbedded in the cytoplasm, but in the latter stages becoming metamorphosed into a mass of yolk-granules, among which one may still see the nucleus. The ducts leading from the follicles on either side of the median line finally unite to form one great transverse canal situated immediately in front of the ovary. On the left side this becomes distended into a yolk reservoir, from which a relatively slender tube arises from about the center of its dorsal, or at times posterior, surface, and coursing toward the right unites with the oviduct, and further on enters the midst of the seminal receptacles (fig. 13, *s. r.*). The latter consist of delicate, thin-walled vesicles, usually seven in number, grouped about and opening into the oviduct. From this point this last named canal passes forward, and enters the egg-mould or oötype of van Beneden. In close proximity to the point of union of the two are a large number of unicellular glands, the shell glands, whose general position and appearance is represented in fig. 13, *s. g.*

The oötype is elliptical or pear-shaped in form, with the pointed end directed toward the exterior. Its walls are relatively thick, and are composed of masses of cells arranged in the form of three pads, as shown in fig. 13, *o*. Each consists of finely granular protoplasm, and contains several distinct nuclei, but no farther indication of a number of

fused cells. The lining of the mould, and the covering of these pads, is a distinct cuticle whose free surface is beset with great numbers of minute hemispherical bosses, which in cross-section give the cuticle a beaded appearance. Numerous fibers, muscle and connective tissues, attach to the outer surface of the mould, form a mesh-work about it, and externally unite with a thin structureless sheath upon which one may detect a few muscle fibers and spindle-shaped nuclei. Beyond the oötype these various investing sheaths form a narrow tube, the uterus (fig. 13, *u.*), which unites with the genital cloaca or genital atrium of Goto a short distance from the external opening. The vagina (fig. 13, *v.*), which may correspond to the canal of Laurer, though this is by no means an assured fact, is under usual circumstances a relatively small and inconspicuous structure. Arising from the anterior surface of the yolk reservoir, it extends with many loopings and windings to the exterior at a point on the ventral surface of the body a short distance behind the opening of the reproductive system (fig. 11, *u.*). Immediately within the external pore with puckered lips the tube widens, forming a small reservoir which is capable of some distention, as one may sometimes note in living specimens. It is only rarely that this canal contains sperm, and I have never yet seen them in the above mentioned reservoir, which, therefore, more probably serves to admit of the entrance of the penis than as a seminal receptacle. Occasionally one finds the sperm extending from the vagina through the anterior portion of the cavity of the yolk reservoir, and it is without doubt this path which they traverse in reaching the seminal receptacle. It is not an unusual occurrence to find yolk-granules in the inner portions of the vagina, and even in the ovary, but this is undoubtedly a pathological condition, for it only occurs upon the relaxation of the tissues immediately before death.

## VI. The Egg-laying Process.

During the reproductive season some of the yolk follicles situated in various portions of the body may frequently be

seen to liberate a few yolk-granules, which with irregular halting movements make their way into the larger canals, which are thus continually packed with yolk. The second stage in the egg-laying process is the liberation from the reservoir of a small quantity of yolk, which traverses the vitelline canal (fig. 13, *v. c.*) and as it passes the opening of the oviduct apparently creates a suction which draws one egg from the ovary. These products then make their way to the mould, carrying with them a few sperm and the secretion of the shell glands. The tube behind the mould now constricts, and wave-like movements of the latter hammer the yolk and egg into a tetrahedral mass surrounded by a shell. The egg is now expelled with considerable force from the external opening, and is apparently imbedded in the mucous covering of the body of the host. At all events small clumps of ova are thus found in infected fishes. This process is repeated from five to twenty times, when a short period of rest ensues. After specimens have been kept under observation for some time the rate changes and several minutes may be required for the moulding process. It is a common occurrence in *E. squamula* that the secretion of the shell glands ceases an hour or two after individuals have been removed from the host, and the yolk and ova are blown like dust from the mouth of the genital atrium.

## VII. Excretory System.

In living individuals, especially those which are small and transparent, the flame or terminal cells of the excretory system may be seen distinctly. This is notably the case with those located in the superficial tissues of the pharynx. They possess an irregular stellate form (figs. 15, 16), the processes extending from the cell-body a short distance into the surrounding tissues, and almost invariably the main body of the cell contains from one to eight vacuoles filled with a transparent fluid. In some cases, when the animals have been allowed to remain for some time in a small quantity of water, these may unite into one large

droplet, which frequently distends the cell to an almost spherical form.

At the point of union of the terminal cell and the capillary tube with which it communicates the former is indented, and from the base of this depression a slender cilium arises, whose rapid vibration drives a transparent fluid, containing a few highly refractive granules, down the tube. Throughout the first part of its course the walls of the latter are relatively thick, and the lumen pursues a very wavy course, becoming more direct after several such canals have united into a larger tubule.

The products which these tubes convey are finally discharged into the main canals, two in number, which traverse almost the entire length of the animal (fig. 19). Anteriorly each swells into a reservoir, from which a slender duct extends outward and forward, to open by a minute pore on the dorsal surface (fig. 11). In stained preparations the terminal section of this canal presents a puckered appearance, and at times contains a slight amount of some secretion which stains darkly, bringing the pore into sharp relief.

Considerable variation exists among the smaller tubes which discharge into the main canals, but fig. 19 represents a fairly typical arrangement. Invariably a relatively large vessel arises from the anterior extremity of each reservoir, and after passing in front of the pharynx the two unite and on the median line give rise to a short canal which bifurcates and rapidly breaks up into a number of minute branches. These extend to the anterior borders of the body, in among the nerve-cords arising from the brain, over and through the tissues of the pharynx, and in some individuals a comparatively extensive system drains the wastes from the region occupied by the reproductive organs in front of the ovary. This latter area may also be traversed by branches from other vessels arising on the inner side of each reservoir. The latter may also develop on their outer borders outgrowths which extend outward among the yolk-glands and branches of the intestine to the margin of the body.

On either side of each lateral canal several branches arise which extend to all the organs in the posterior half of the animal. Owing to the innumerable yolk-glands only the larger branches may be seen, and it consequently becomes impossible to determine whether they form an anastomosing system. One large canal situated immediately behind the ovary is in some cases, at least, a commissural vessel connecting the two lateral canals, and also giving rise to several small branches which extend into the surrounding tissues. Posteriorly the lateral vessels approach each other, and pass into the pedicel side by side. From sections they appear to unite upon their entry into the disc, though of this I am not certain. From extended observation it seems positive that a terminal contractile reservoir does not exist in this region, nor was any trace whatever found of a median exterior communication. While the main branches and many of the smaller twigs may readily be distinguished in the body proper, no definite trace of them exists in the posterior sucker; and in vain also were terminal cells looked for in the latter. Often after transferring specimens into the clearing agent many delicate canals in the disc have been found, filled with air, but in every case these coincided exactly with some of the larger nerve fibers. Various authors have called attention to the fact that the nerve cords of some of the trematodes appear to traverse a spongy substance which shrinks after treatment with reagents. It accordingly becomes a difficult task to determine whether the above described canals are branches of the excretory system or an artificial product.

As already indicated, the contents of these vessels consists of a transparent fluid containing relatively few refractive granules. In the vicinity of each flame-cell this is driven along by the vibrating cilium, but in the larger vessels irregular peristaltic movements may be seen occasionally. In some cases this appears to be due to the general movements of the body, but at other times it becomes so definite that they seem to be caused by special muscles, though I have never been able to demonstrate their presence.

With the exception of the flame-cells, it has been found impossible to discover any cellular elements in the excretory system. The walls of the finer branches, and particularly the reservoirs and lateral vessels, are excessively thin and apparently structureless and devoid of nuclei.

## VIII. The Nervous System.

The brain of *E. squamula* consists of a relatively short semicircular band situated near the dorsal surface immediately in front of the pharynx. Out of its lateral borders six symmetrical nerves arise (figs. 1, 2, 5), four ventral and two dorsal, which extend the length of the body and terminate in the posterior sucker. Both the brain and these longitudinal cords give rise to smaller nerves, whose general arrangement may be determined from sections and stained preparations; but with the use of methylen blue many additional details appear which are otherwise hidden. A small quantity of the stain is added to the sea-water in which the living animals are kept, and after from one to three hours various elements of the nervous system become stained, and may be studied for several hours if kept cold. They may also be preserved by using saturated ammonium molybdate as a mordant, and then passing them rapidly through various grades of alcohol and mounting in balsam.

The large nerves which pass out anteriorly from the brain are six in number (fig. 5). In addition to these, from two to six extremely small fibers sometimes appear on each side, but they are probably included in some of the large nerves ordinarily. A short distance beyond the brain all these nerves unite with a second cord, also semicircular in form, and concentric to the brain. From this commissure a number of nerves arise which supply the anterior end of the body.

The most anterior pair of nerves arising from the brain passes forward, giving off fibers to this semicircular commissure, and, continuing onward into the space between the two adhesive organs, breaks up into a fine brush which extends into the tentacle-like projections on the anterior margin

of the body. The remaining pairs of nerve-bundles join the semicircular commissure, and many of their fibers may be traced into some of the several nerves which pass on into the substance of the sucking discs. Posteriorly the commissure bends inward on each side, and unites with the brain at the origin of the outer longitudinal cords.

As Lang noted in *Tristomum molæ*, the brain is not only symmetrical in form, but the constituent cells of one side find their counterpart in the other. In *E. squamula*, this is not only true of the brain, but of the nerves and semicircular commissure above described. Throughout these cords bipolar cells are of frequent occurrence, and generally one nerve from each may be traced close to the surface of the body, while the proximal fiber passes into the substance of the brain. In a few cases the proximal nerves, instead of traversing the brain of the same side, cross over and decussate with the fibers from corresponding cells of the opposite side. Another interesting arrangement is found in cells of a tripolar type, two of which are shown in fig. 5. Here one nerve leads to the brain; another passes into the substance of the sucker on the same side; while the remaining fiber passes across to innervate the sucker of the opposite side. Other less frequent or more complicated types may perhaps be described in a future paper.

As noted above, the inner and outer pairs of great longitudinal nerves arise from the lateral borders of the brain, and extend through the body, to break up into a complex system of nerves within the posterior sucker. In passing through the pedicel they are of necessity brought close together, but the paths which they pursue in reaching this point are considerably different. The inner pair, the stronger of the two, in passing backward diverges slightly to skirt the ovary, and more widely to clear the testes. From this point onward they gradually approach each other, and enter the sucking disc close together. Each cord of the outer pair directs its course toward the lateral margins of the body, which it follows to the posterior end of the animal. Here it unites with the inner longitudinal

cord of the same side, and probably with one of the longitudinal fibers which form part of the dorsal nervous system. We thus have two nerves entering the disc on each side of the median line, each of which is the combined product of two ventral and one dorsal cord.

Upon entering the disc each nerve passes outward a short distance (fig. 2), and divides into two branches, one extending forward, the other backward. The former, after giving rise to several small nerves which supply the anterolateral portions of the disc, unites with its fellow of the opposite side, forming an anterior, semicircular commissure. From this, four well defined nerves pass forward, and branching freely, supply the anterior portion of the disc, including its marginal membrane. The nerves passing backward are united by a commissure which passes through the center of the disc. Beyond this point each breaks up into a series of fibers which penetrate throughout the posterior half of the sucker. The finer branches of each nerve form an anastomosing network of fibers which appear to unite with similar anastomoses which are the product of large branches in other parts of the disc.

Returning to the four ventral longitudinal cords, we find them constituting a part of an extensive system which in some respects resembles that of *Tristomum molæ*, as determined by Lang (1881). Between the inner pair are from eighteen to twenty-four commissures, of which the first one is excessively delicate, and consists of a very few nerves. It is perfectly constant, however, and lying against the pharynx may be traced to each side to a point a short distance posterior to the first commissure between the inner and outer longitudinal nerves. The succeeding connectives, which cross the reproductive organs, are also delicate, but they usually stain readily with methylen blue, and are then easily followed. Behind the testes the cross nerves become stronger and are demonstrable in sections. The nerves uniting the inner and outer cords are larger, and in many cases arise opposite the roots of the inner commissures. Unlike the latter, the most anterior one is very strongly developed, while the succeeding ones are of smaller caliber.

In the spaces formed by these commissures and the longitudinal nerves is an anastomosing system of delicate fibers which originate at irregular intervals along the larger cords. The nerves extending outward from the outer pair of longitudinal cords also break up into a complex network which extends to the margin of the body. In some cases nerves from some of these smaller branches appear to terminate close to the surface in a number of excessively fine branches beset with indistinctly marked varicosities. The greater number, however, give off short branches which attach to the numerous muscle fibers lying close to the surface of the body.

As noted above, the dorsal pair of nerves arises on each side of the pharynx at the point of origin of the ventral longitudinal cords. From here they pass to the dorsal side, and lying just beneath the superficial musculature, extend the length of the body. Their course throughout is almost parallel, which accordingly brings them closer together than the inner ventral pair. In the most favorably preserved and stained preparations they may be traced to a point on each side of the ovary, where they apparently end. In specimens treated with methylen blue, however, they are found to continue to the end of the body, and to give rise to a system of nerves which is but little less extensive than that of the ventral side. At frequent intervals commissures arise, and toward the outside numerous nerves are given off which soon branch, forming a plexus whose meshes grow smaller and smaller as the margin of the body is approached.

Along the path of some of these nerves bipolar cells are occasionally found, but they are of comparatively rare occurrence. Situated a short distance from each longitudinal cord, usually to the outside, are at least twenty multipolar cells of relatively large size, which are relatively more abundant in the anterior half of the body. With methylen blue these cells stain intensely, and some of the fibers passing off from them often have a coarse irregular appearance when compared with the smooth delicate nerves in other parts of the body. In many instances, four or five nerve

fibers arise from each cell, one or two of which enter the longitudinal cords (fig. 8), while the others join some of he neighboring commissures or their smaller branches. In addition, there are often several protoplasmic processes (dendrites) which form a confused tangle about each cell, or passing outward end freely at a short distance.

Lying along the median dorsal line of the body, and therefore half-way between the main longitudinal nerves, is a nerve cord which extends from the hinder end of the pharynx to the posterior sucking disc. All the commissures connecting the longitudinal strands appear to unite with it, and anteriorly it apparently terminates in the first connective, for in no case have its fibers been traced farther forward. From this point backward to the ovary, it includes six or eight large nerve cells similar to those described in the preceding paragraph, whose main fibers traverse the median cord, while the others may extend into the connectives. Posteriorly, it passes into the pedicel exactly in the median line. Its caliber, like that of the dorsal pair of longitudinal nerves, is exceedingly small as it enters the stalk, and owing to this fact I have been unable to determine accurately the posterior relations of the dorsal nervous system with the ventral. Each of the paired dorsal nerves may be traced to within a short distance of the point of union of the outer and inner ventral cords, but in spite of continued effort their union has never been observed.

As in the ventral nervous system, the dorsal nerves innervate the great superficial muscles or end freely close to the surface of the body, and are therefore probably sensory. The ventral musculature is more highly developed than the dorsal; accordingly the motor nerves in this region are relatively more abundant. The excess of nerve terminations on the ventral surface is to be explained by the fact that this area rests against the host.

## IX. VISUAL ORGANS.

The eyes, four in number, and having the appearance of small pigment spots, are only partially imbedded in the

dorsal surface of the brain. As Lang (1881) has stated for *Tristomum molæ*, they are located "in den vier Ecken eines niederen Trapezes, dessen Basis nach hinten gekehrt ist. Sie liegen ferner so, dass die Öffnungen der Pigmentbecher je der zwei auf einer Seite liegenden Augen einander zugekehrt sind. Bei Beobachtung des lebenden Thieres hat man öfter Gelegenheit zu sehen, wie die vier Augen simultan eine zuckende Bewegung ausführen. Dies thun sie meistens nach ziemlich langen Zwichenräumen und zwar in der Weise, dass je die zwei Augen einer Seite gegen einander zu zucken." In *E. squamula* one pair of eyes usually moves simultaneously with the other, though this is by no means invariably the case. And furthermore, if the animals are fresh, and consequently vigorous, the movements may take place with the rapidity of the pulse beat. With these two exceptions, Lang's observations may be extended to *E. squamula*.

From the study of sections and living animals, especially those which have been treated with methylen blue, I am also able to confirm Lang's observations regarding the finer structure of the eye. As in *Tristomum molæ*, each of the four eye-spots consists of an almost spherical, highly refractive, transparent body, which, in many cases, contains one or two small vacuoles; but, so far as I am able to judge, no nucleus is present. This lens is partially covered by a cap of dark brown pigment granules. These two elements are imbedded in a comparatively large ganglion cell, which has been termed by Lang "eine typische Ganglion-zelle als Retina." Whether these nerve cells completely enclose the lens or not cannot be said with certainty. If they do, the film lying outside of the pigment cup is exceedingly thin. In every case, from two to three fibers arise from each ganglion cell, and extend some distance into the substance of the brain. Furthermore, as Lang has shown for *Tristomum molæ*, a series of delicate muscle fibers is situated in close proximity to the eyes, and is iustrumental in producing the rotation noted above. All of these elements are constant, and the arrangement rarely departs from the plan shown in fig. 18.

While the eyes of all the species of the genus *Epidella* are constructed upon the same general plan, Goto in his excellent paper on the Japanese ectoparasitic trematodes calls attention to the fact that in *E. ovata* they are useless as visual organs. "Morphologically speaking they are certainly degenerate eyes, and have probably been derived from some such eyes as are found in the Turbellaria; but I do not think they are functional. In the first place, the pigment granules are situated on the dorsal side and thus prevent the light from reaching the lens, since it is the only direction from which the light can come. In the second place, there is not always a distinct retina. In *Tristomum molæ*, the species studied by Lang, the retina is said to be present; but in *Tristomum ovata* there is none, since the ganglionic cells in the immediate vicinity of the lens already mentioned are not in such a position as to receive the light that has passed through the lens."

In the case of *E. squamula*, living on the underside of a fish which rests on the bottom for the greater part of its time, the pigment on the anterior side of the lens is placed in a most favorable position. As already mentioned, the eyes are located on the dorsal side of the brain. The tissues between it and the exterior are clear, and the light passing in under the fish must of necessity strike the lens and affect the retina, which is always present.

Furthermore, Goto considers the eye muscles to be merely dorsoventral muscle fibers similar to those found in all parts of the body. Accordingly the eyes are passive, "the worm having no power to direct its eyes in any special direction." It may be true that these eye muscles are the homologue of the dorsoventral bands, but in *E. squamula* the movements they produce, usually simultaneous, cause a definite rotation of the eye, and appear to me to be sufficiently specialized to be considered true eye muscles.

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## EXPLANATION OF PLATE XV.

All drawings made at the level of the microscope stage, with the aid of camera lucida.

Fig. 1. The dorsal nervous system of *Epidella squamula*, sp. nov. The two main longitudinal nerves are represented, together with their commissures and numerous branches, which form a loose anastomosis.

Fig. 2. The ventral nervous system, showing two pairs of longitudinal nerves, their commissures, and branches. The chief nerves of the posterior sucker are also shown.

Fig. 3. One of the two reservoirs of the excretory system in a distended and collapsed condition; *e*, external opening. From same individual.

Fig. 4. Transverse and longitudinal sections of two of the cells located within the terminal third of the vas deferens.

Fig. 5. Somewhat detailed drawing of the brain; *a*, anterior sucking discs; *b*, brain; *c*, semicircular commissure; *d*, dorsal nerves; *o. v.*, outer, and *i. v.*, inner ventral nerve cords; *ph.*, pharynx.

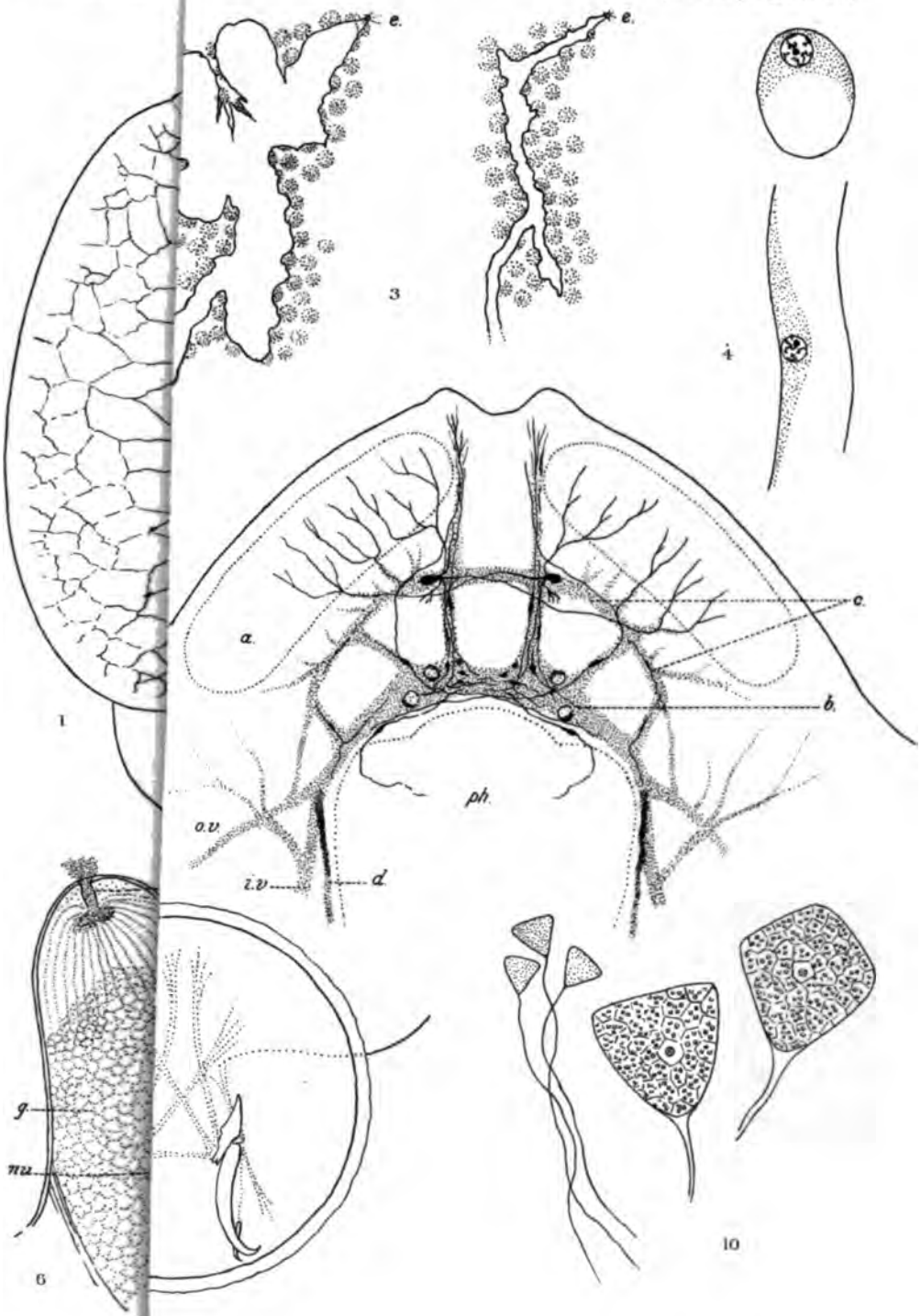
Fig. 6. One of the pharyngeal gland cells, showing nucleus (*nu.*), the secreting portion (*g.*), numerous intracellular ducts (*ca.*), the reservoir (*re.*), and outer opening.

Fig. 7. Two of the four groups of cells lying directly behind the testes (*t.*).

Fig. 8. One of the ganglion cells lying beneath the subcuticular muscle bands. The inner longitudinal nerve is about one-fifth its correct diameter.

Fig. 9. The posterior sucker, showing the three pairs of hooks and some of the chief muscles which operate them.

Fig. 10. The eggs of *E. squamula*, showing the centrally placed ovum surrounded by yolk-cells.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## EXPLANATION OF PLATE XVI.

Fig. 11. The reproductive system: *a.*, anterior sucking discs; *b.*, brain; *e.*, outer opening of excretory system; *ov.*, ovary; *re.*, excretory reservoir; *t.*, testis, *u.*, uterus; *v. d.*, vas deferens; *y. d.*, yolk-ducts; *y. f.*, yolk follicle.

Fig. 12. The digestive system. The position of the salivary glands (*s.*), the prostate glands (*p.*), and glands passing into the posterior sucker are also shown.

Fig. 13. Diagram of the reproductive system: *o.*, oötype, or egg-mould; *ov.*, ovary; *p.*, ducts from prostate glands; *p. r.*, reservoir for prostate secretion; *s. g.*, shell glands; *s. r.*, seminal receptacle; *u.*, uterus; *v.*, vagina; *v. c.*, vitelline canal; *v. d.*, vas deferens; *y.*, yolk reservoir; *x.*, problematical cells lining the vas deferens.

Fig. 14. Longitudinal section through the body: *b.*, brain; *o.*, oötype, or egg-mould; *ov.*, ovary, *ph.*, pharynx; *pr.*, prostate reservoir; *s.*, gland cells passing into sucker; *t.*, testis; *y.*, yolk reservoir.

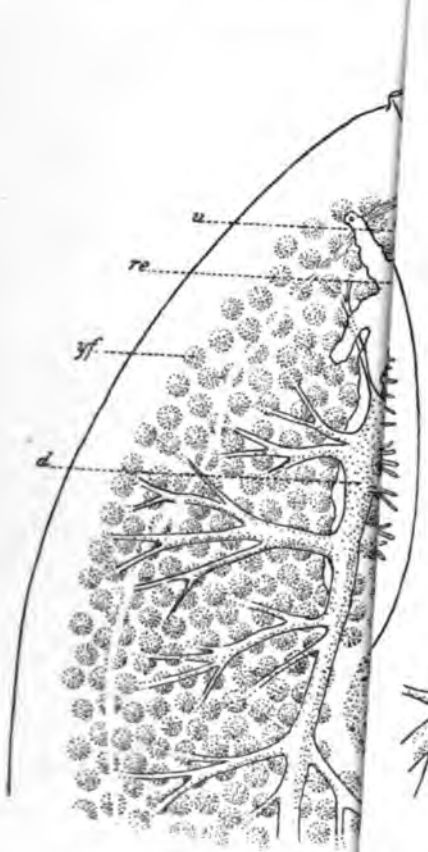
Fig. 15. Terminal excretory (flame) cells: *a. b.*, distended with waste matters.

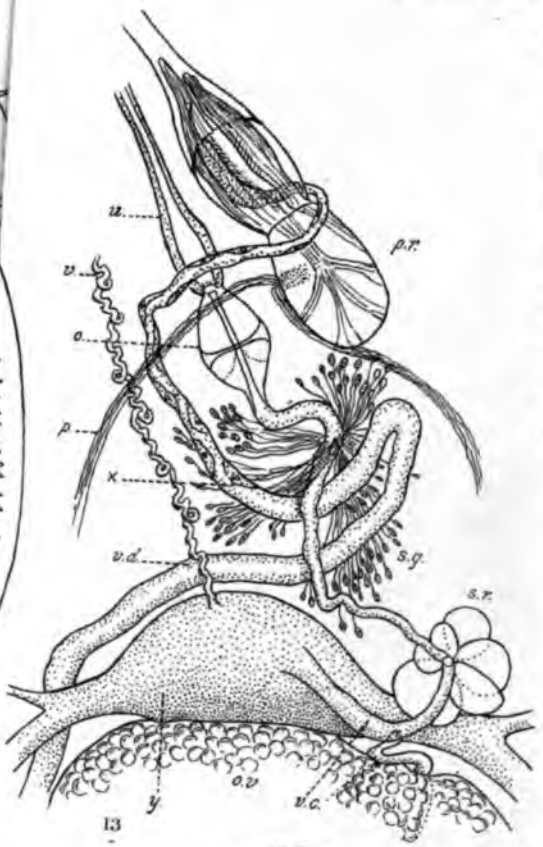
Fig. 16. Excretory cells and connecting branches.

Fig. 17. Longitudinal section through the pharynx. (For explanation see text).

Fig. 18. The eyes, which normally are farther apart. (*Cf.* fig. 5).

Fig. 19. The excretory system: *re.*, excretory reservoir.

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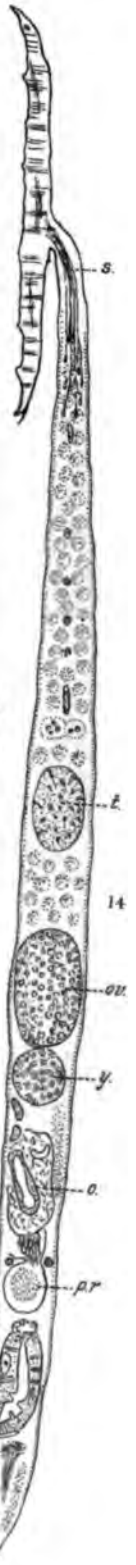


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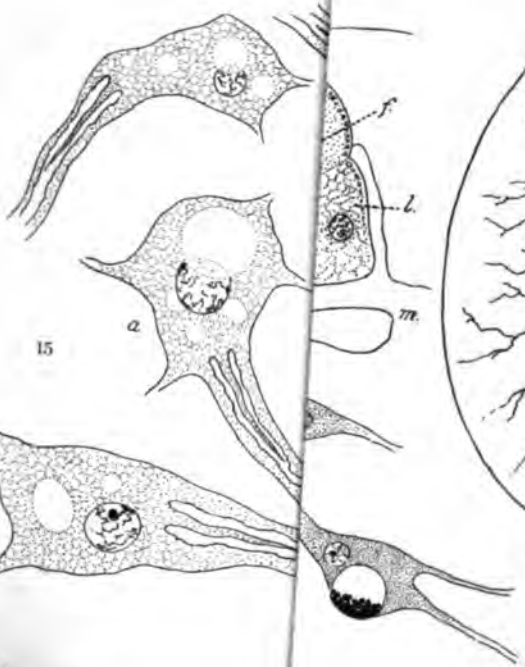


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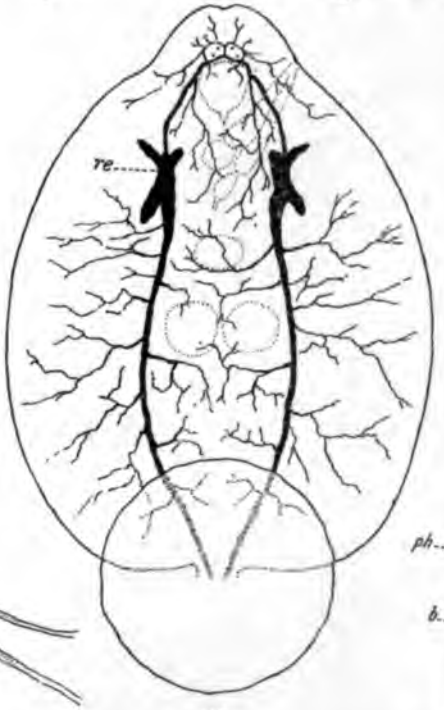


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# Variation and Fusion of Colonies in Compound Ascidians

BY

FRANK W. BANCROFT

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BY FRANK W. BANCROFT.

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## I. INTRODUCTION.

THESE investigations were carried on at Woods Hole during the summer of 1898, and at Naples, from April to November, inclusive, 1899. They were made possible by an appointment to a Parker Fellowship in Harvard University, for which the writer wishes to express his thanks. Thanks are also due to the United States Fish Commission for the advantages enjoyed at its laboratory at Woods Hole, and especially to Professor H. C. Bumpus, for the excellent opportunities for research afforded. Furthermore, thanks are due the Smithsonian Institution and the committee in charge of the University Table for the use of their tables at the Naples Zoölogical Station. Finally, it is the pleasant duty of the writer to record his obligations to Geheimrath Dr. Dohrn and the staff of the Zoölogical Station at Naples for the constant kindness with which all his wishes were met.

This paper is concerned only with the study of living colonies of *Botryllus* and *Botrylloides*, both incrusting compound ascidians. To facilitate the handling of the animals and allow an examination of both upper and lower surfaces, the colonies were reared attached to glass slides. They were easily fastened to the slides by tying down the edges, especially those containing the ampullæ. In vigorous colonies kept in their natural environment one or two days sufficed for forming a firm attachment, when the strings could be removed. When, however, the colonies were kept in aquaria, the attachment took place more slowly.

It was found that colonies kept in aquaria would not do well. They would live for months and bud regularly, but would not grow vigorously nor reproduce sexually. Accordingly, the slides, with the colonies attached, were fastened on the under side of a board that was kept floating in the bay near where *Botryllus* was growing of its own accord. By means of thus placing them in their

natural habitat, vigorous growth and sexual reproduction were easily obtained. Many other animals attached themselves regularly to the slide; in fact, bryozoa, worms, barnacles, and other ascidians often grew there so vigorously that they had to be removed periodically to save the *Botryllus*. There is nothing more fascinating than to watch the waxing and waning of these other species. The rapidity and suddenness with which some forms appear and disappear, sometimes without having been crowded out by competition, is absolutely dramatic. This method of setting out slides in the normal habitat of the animals to be studied is much to be recommended, not only for investigations similar to those here described, but also for faunistic and etiological studies.

In order to follow the development of the brother and sister colonies produced by the same mother, a colony containing larvæ that were nearly ready to hatch was isolated in a dish, the sides of which were lined with glass slides. When the larvæ hatched, many of them attached themselves to the slides, which were then removed and marked with a diamond. A drawing was made of each slide, natural size, showing the exact location of each of the embryozooids, so that later on the slides could be placed over the drawings and any embryozooids that had subsequently attached themselves to the slides could be discovered and removed. The slides were examined in this way at intervals, and all the foreign colonies removed, so that there could be no doubt concerning the ancestry of any of the colonies. In this way the three families of colonies, which furnished most of the material for the study of color variation and fusion of colonies, were reared.

## II. NATURAL HISTORY.

The enemies of *Botryllus* and *Botrylloides* are of two kinds: First, the enemies proper that prey upon the colonies and eat them; second, the competitors that have need of the same surface to which to attach themselves

and of the same food supply, and compete with *Botryllus* for both. Of these, the second class is much more important and harmful.

It was only at Naples that any of the enemies proper were encountered: but at one time they caused serious trouble, large portions of some of the colonies being removed from the slides each day. The enemies seem to have been crabs, for when the board with the slides was removed from the bottom of the boat, to which it had been attached, and left floating where none of the animals crawling about on the boat could reach it, these depredations ceased. In the aquarium, also, crabs were found to remove *Botryllus* from the slides, and eat it with avidity. The writer could not see that any preference was evinced for any particular color of *Botryllus:* so it would seem that their brilliant colors cannot be considered as warning colors. When, however, *Botrylloides rubrum* was fed, pieces of the colony were at first detached, but were not eaten, and later the colony itself was not molested. Here, then, it might be said that there is a warning color, associated with an unpleasant taste, but the case of *Botryllus* makes it probable that even here the conspicuous color has not been developed as a warning color.

The mortality of the young colonies, especially of the embryozooids, is very great. It was determined for three lots of sister colonies.[1] In the first (fourteen individuals), only one, or seven per cent, lived beyond the sixth day: in the second lot (seventy-five individuals), twenty-five per cent were alive on the eighth day: and in the third lot (fifty-nine individuals), seventy-four per cent were alive on the ninth day, and fifty-seven per cent after one month. Some of these colonies, consisting of an embryozooid or first blastozooid, were undoubtedly removed bodily from the slides by their enemies; but the greater part were found still attached to the slides after decomposition had set in. Thus, in the first and third lots, the numbers of young

[1] When the locality whence the colonies are derived is not stated it is understood that they were Naples, and not Woods Hole, colonies.

ascidians that died were thirteen and fifteen respectively, and of these twelve in each lot were found attached to the slides after death. The cause cannot have been crowding, for the embryozooids were usually situated one centimeter apart, or more; therefore, death must have resulted from some disease or a general inability to cope with the environment. One of the main difficulties that the embryozooids have to contend with seems to be the acquisition of a sufficient quantity of food to tide them over the period during which the first blastozooid is formed. The embryozooid is not able to go on growing and assimilating indefinitely until it has reached a sufficient size so that the first blastozooid can be safely formed. Its existence is limited to about six days; then it degenerates and the growth of its bud is accelerated. But there is usually a period of about a day during which the siphons of neither embryozooid nor blastozooid are open, and during which no food can be taken in.[1] It is only very exceptionally that the young colony is so vigorous that the development of the first blastozooid can be effected without the resorbtion of other parts of the colony besides the embryozooid. The tips of the ampullæ are almost invariably retracted away from the edge of the test to which they formerly reached, their volume is considerably diminished; and sometimes the whole common vascular system is resorbed to such an extent that it can hardly be detected at all.[2] It is here that we have a source of danger which is probably responsible for a good part of the mortality of these young colonies. It is in the earliest stages, then, that there is

[1] Pizon (1899 and 1900) has studied in detail the length of life of the zooids in *Botryllus* and *Botrylloides*; but, as might have been expected from the fact that his colonies were observed in aquaria, while those of the writer were observed in their natural habitat, his figures do not agree very closely with those of the latter. A detailed comparison will not be attempted here, but in general it may be said that while in the colonies studied by the writer the adult life of any generation of zooids was equal to or longer than that of the zooids studied by Pizon, the time from the beginning of the degeneration of the old generation to the adult condition of the next generation (marked by the opening of the siphons to the exterior) is very much shorter. This latter period was sometimes even reduced to less than zero, the siphons of both generations being open at the same time.

[2] For a discussion of the results which Pizon (1900) has arrived at with respect to the decrease in the size of the ampullæ, see Appendix.

the greatest opportunity for the action of Natural Selection, and the individuals that are selected appear to be those possessing the greatest vigor—the ones that can absorb food best and can grow fastest; both of them qualities that are of the utmost importance during their later life.

The life of the adult colonies has been observed under two conditions. First, when the substratum was practically free from other organisms; second, when the colonies had to compete with other organisms for a substratum to grow on. The first state of affairs was encountered principally at Woods Hole and Newport, where *Botryllus* is usually found attached to the eel-grass, but also on the under sides of rocks, floating boards, etc. On the rocks and boards large colonies, equaling a hand in size, were often encountered. On the eel-grass, however, and especially in the eel-pond at Woods Hole, where *Botryllus* was very abundant, the colonies were much smaller. This small size was undoubtedly due to the competition of the large numbers of neighboring colonies; for they were so crowded together on the tips of the blades of eel-grass that there was no room to grow large. Furthermore, every sign of vigorous competition was present. The colonies were fitted accurately against each other with no space between. Their area of attachment having been limited, they had grown thicker than usual; especially so at the edges where one colony adjoins the next. The whole presented the appearance of stable equilibrium: the contestants were of equal strength, armed with the same weapons, and a deadlock had ensued.

At Naples a different spectacle presented itself. Here the floats and slides were being constantly overgrown by other organisms, mostly branching hydroids and bryozoa, with which only a few of the strongest *Botryllus* colonies could successfully compete. But even in these cases nothing resembling stable equilibrium was established. The only salvation of the *Botryllus* colonies seemed to consist in growing rapidly and constantly conquering new territory; even growing out on the branches of their

enemies and covering them. The edges were the most vigorous parts of the colonies. Thus it was frequently seen that the edges of one colony would grow onto new territory, while the less vigorous central parts would succumb to the attacks of enemies and die. Occasionally the central parts would lose vigor and die of their own accord.

### LENGTH OF LIFE OF BOTRYLLUS COLONIES.

The maximum age of *Botryllus* colonies seems to be less than a year. The oldest ones of which the writer has records were six months and twenty-three days old. Some of these were in fair condition when observed for the last time, and undoubtedly lived considerably longer. The great majority of the colonies, however, died before they were so old, in spite of all the care that could be bestowed on them, such as removing competing organisms from the slides and giving them a perfectly natural environment. The cause of death was apparently simply old age. They had lost their vigor, and for some time before death had been decreasing in size, until finally they could no longer assimilate enough food to keep them healthy; and so died. At death, the colonies were never very large, but often had a fair size, consisting of from six to ten systems. No such thing as an æstivation or hibernation of the colonies, during which they might lie dormant for a period, and then grow with renewed vigor, was observed; although during the same period such phenomena were observed in *Botrylloides*. Accordingly, all things considered, it seems certain that, in the great majority of cases, the age of a *Botryllus* colony is under a year.

## III. COLOR VARIATION.

Most of the statements recorded in this and the following sections are based upon the observation of three families, each composed of a single mother colony, and the brother and sister colonies derived from the larvæ extruded by a

single generation of zooids of the mother colony (Family I, figs. 1–15; Family II, figs. 16–23; Family III, figs. 24–25.) The methods employed have already been described on page 139. Of these three families the first comprised at the outset ninety-two colonies, of which thirty lived to develop their mature color patterns. The second family started with two hundred and sixteen colonies, and of these seven lived to have their colors recorded. The third family began with four colonies, of which two reached color maturity. Most of the colonies that lived to develop their mature color patterns were under continuous observation for several months; the longest-lived of them for nearly seven months.

The color variation will be discussed in two sections: first, the general character of the color variations observed will be described; and second, the data thus obtained applied to the consideration of the characters which may safely be used to separate the described species of *Botryllus*.

### *A.* Nature of the Color Variation.

As has long been known, the colors of *Botryllus* are due to the many colored pigment-cells which it contains. In general, each colony contains cells of three colors: first, light colored cells, either white, light yellow, light green, or yellowish green; second, dark colored cells, black, brown, or deep blue; third, yellow, red, or orange cells. In any one colony the color of each of these three classes of cells is usually quite constant at any particular time. Thus, no colony ordinarily has white and light green, or brown and blue cells, but the variations present are caused by different dispositions of cells of comparatively constant colors. During the life of the same colony, however, and also in succeeding generations of colonies, the color of each of these three classes may vary considerably. Reference to the figures will show what variations these three colors underwent, and how they were combined in the three families studied.

The color patterns are numerous and varied. They may be developed either by the absence, in certain regions, of the pigment-cells making up the ground-color of the zooids (figs. 23, 26), or by the addition of certain pigment-cells in places (figs. 16–22). Some of them can be seen to be based upon a structural foundation. In all probability they are all merely accidental concomitants of the morphology of the region containing them, and are of no use in the struggle with the environment. This is seen most distinctly in the case of internal organs which do not show from the outside, but which still contain definite arrangements of pigment cells. Thus the endostyle always contains a large amount of dark-colored pigment, as can be seen in most of the figures where the branchial orifice is opened wide enough. The stomach is marked also with yellow and black pigment.

Although but little attention has been devoted to the subject, it was seen that some of the lines that go to make up the external color patterns are coincident with superficial blood sinuses. This is true of the line in the mid-dorsal region (figs. 1, 7, 10, 21, 23) and the light colored circle about the branchial orifice, most distinctly marked where it cuts the median dorsal line (figs. 1, 7, 10, 11, 22). This circle is also superimposed upon the peripharyngeal band. There is no doubt that many other instances could be found by devoting special attention to the subject.

The variations observed in the colors of *Botryllus* zooids fall under the following heads:—

1. Variations of the same zooid at different ages.

2. Variations among the zooids present in the same colony at the same time.

3. Variations occurring at different times in the same colony.

   (a) Due to age.

   (b) Due to external influences.

4. Variations among the brother and sister colonies produced by the same mother colony.

These classes will be taken up in order.

### 1. VARIATIONS OF THE SAME ZOOID.

These are not particularly great in themselves, but as one colony contains only adult zooids of one generation at the same time, and as these all develop together, the aggregate effect may be quite striking, and the general appearance of the colony altered a good deal. Hence, in comparing different colonies, or pieces of the same colony, it is always necessary that the zooids be in the same phase. Figures 5, 6 and 7 show the amount of variation that normally occurs during the life of the same zooid. Often, however, it is much greater. Figure 5, drawn when the zooids were young and their parent generation had not yet entirely degenerated, shows the extreme variation in ground-color which a single zooid in this colony underwent. Figures 6 and 7 are drawings of the two young zooids represented in fig. 5, drawn respectively one and two days later. They show to a small extent the elaboration of the color pattern with increasing age. Where the color pattern is more complex (as in fig. 10) this phenomenon can be noticed much better. Then the *young* zooids present no pattern at all, and it takes three or four days for the final pattern to be evolved.

### 2. VARIATIONS IN DIFFERENT REGIONS OF THE SAME COLONY.

At Newport and Woods Hole nothing of this kind was noticed. In all the colonies examined, all of the zooids had exactly the same color. At Naples, however, the case was different. Possibly the reason for this difference was that at Naples a larger proportion of colonies were examined that were not in their prime. When describing the habits of growth of the Naples colonies (p. 143), it was mentioned that the edges of the colony were often more vigorous than the central parts. Accompanying this difference in vigor there is sometimes a difference in color. Thus, in about one hundred colonies twelve were found

exhibiting this difference. Although the colonies were of many different colors, the variation was the same. It consisted in an increase in the proportion of red pigment in the more vigorously growing edge. The following differences were observed:—

Whitish and very light yellow colonies had a reddish edge.

Distinctly yellowish colonies had an orange edge.

Brownish colonies had a reddish brown edge.

Bluish black colonies had a purple edge.

An extreme case of this variation, from another lot of colonies, is shown in figs. 26 and 27, the last figure showing the average condition on the edge and the first in the center of the colony. In one of the colonies that was watched most closely (represented by figs. 17–21) the zooids on the growing edge had about the same general tone as the rest of the colony, being usually yellowish, though sometimes darker; but differed from the central zooids in that the white dorsal double bands were more feebly developed. Thus, at the time when figs. 20 and 21 from the growing edge were taken, the condition of the double bands in the rest of the colony was about that represented in figs. 17 and 19.

### 3. VARIATIONS OCCURRING AT DIFFERENT TIMES IN THE SAME COLONY.

*(a) Due to Age.*—Mature ova and young embryos are salmon-colored (fig. 8), on account of the yolk they contain; but as they grow older they become a very transparent pink. When hatched, the larvæ have the same color, with a small amount of yellow and black pigment. Young colonies with no more than a single system are still more transparent. Their pigment is mostly confined to endostyle and stomach. As they grow older, they become pigmented on the surface, so that the internal organs do not show through, but the colonies are still transparent looking (figs. 9, 15). It is now that the color patterns can

be made out for the first time. A little later sexual reproduction begins, and the colonies may be said to be adult. Most of the figures are taken from adult colonies. As old age comes on, the pigmentation becomes progressively deeper, and most of the color patterns again disappear. Figure 16 shows the appearance of a colony that is about to die. In its prime it looked more like the white-striped zooids in fig. 23 (one of its offspring), having distinct dorsal double bands and being much lighter colored. To sum up, then: *The older the colony the more deeply pigmented it is. Distinct color patterns are characteristic only of colonies in their prime, being much less developed at both ends of the series.*

*(b) Due to External Influences.*—The only external influences that have been tested are unfavorable conditions, such as exist in the aquaria, and in their natural environment when the competition of other organisms is too strong. Figure 2 represents a system of a colony that had been kept in a small aquarium with running water for seventeen days. Other pieces of the same colony that had been kept in the bay had the appearance of fig. 8, except that the thin white coating on the posterior half of the zooids was lacking. A piece of another related colony, which, before being put in the aquarium, had the appearance of fig. 1, except that the cloacæ were colored black, underwent the same change. After fifty-nine days in the aquarium it had exactly the appearance of fig. 2. When removed from the aquarium and put back in the bay, pieces of these colonies that had assumed the red color sometimes regained their former vigor, and with it their former color. When they did not do this they soon died. Figures 11 and 12 represent another case. They are both from the same colony, fig. 11 representing the colony in its prime, and fig. 12 after it had been badly overgrown by hydroids and was in rather poor condition.

Besides changes like those mentioned, there are many others whose cause cannot be so definitely made out.

They are probably dependent upon changes in the vigor of the colonies due to age and environment. In fact, with few exceptions, all the colonies were constantly changing their colors. Thus, at one time, the colony represented by figs. 17 to 21 was in many pieces, distributed upon a number of slides. Although they had all been fastened to the same board, where the environment should be comparatively constant, the different pieces hardly ever had the same appearance. Thus, on one day the ground-color varied from transparent gray to dull black, and to dark brown, with all gradations in between. The double bands were present in all cases, and of medium thickness. To show the character of some of the changes, part of the records for one colony is here given.

*August 1.* (Fig. 8.) There is a good deal of variation in the colony, due to differences in the thickness of the coating of light-colored pigment, so that sometimes the zooids have their anterior half dark and their posterior half light colored; sometimes they are streaked longitudinally with black and white; and sometimes they are almost entirely black near the cloaca, white in the middle, and brownish yellow at the anterior end.

*August 18.* PIECE I.—In good condition. Figure 8 still represents a good average zooid.

PIECE II (on another slide).—The colony is growing, but not very well. The color is intermediate between figs. 1 and 8, nearest 8; but some of the zooids have no white coating at all, only irregular markings and a few sparse, isolated dots. A few zooids have a well developed coating.

*September 2.* PIECE I.—Color darker than fig. 8. The coating is a decided lemon yellow.

*September 8.* PIECE I.—One end of the colony with younger zooids has very distinct yellow coatings, while at the other end the older zooids, which have buds nearly ready to replace them, are streaked and without any distinct coating.

PIECE II.—In fair condition; it has been in the aquarium for one or two weeks. Color is Van Dyke brown with streaky yellow coats.

*September 16.* PIECE I.—In fine condition. The color differences observed on the eighth still persist, but the coats are not so distinct.

*September 26.* PIECE I.—In fair condition. On the right the coats are better developed than on the left.

*October 11.* PIECE I.—Badly overgrown with calcareous worm-tubes and hydroids, but still in fair condition. The color of the coats varies from orange to greenish yellow. The ground-color varies from a light to a very dark brown.

### 4. VARIATIONS AMONG COLONIES PRODUCED BY THE SAME MOTHER.

These variations are more extensive than any previously mentioned, and in addition, are often characterized by a decided discontinuity. The variation in the species as a whole, however, is continuous, all gradations being encountered; so that a continuous series seems to be produced by the summation of the variants of a large number of families, each of which normally consists of a discontinuous series.

The colors of the zooids are made up of three constituents:—

*(a)* The ground-color.

*(b)* Some of the lines and spots making up the color patterns in some zooids. In the main these are the markings discussed on page 145, and their position seems mostly to be due to underlying blood-vessels. They are usually quite variable in the same colony, and disappear entirely in old age.

*(c)* Other color markings which cannot be distinguished from those of class *(b)* by inspection, but behave very differently from them so far as variation is concerned.

For, though occasionally variable, they are the most constant color characters that a colony possesses. Their position does not seem to depend on blood-vessels. The best example of markings of this kind was found in the two parallel white bands extending from cloaca to branchial orifice (figs. 17, 23).

*(a) The Ground-Color.*—This is almost always lighter (yellower or redder) toward the anterior end of the zooid, around the branchial orifice, and blacker towards the cloacal orifice. The extensive white coating towards the cloacal ends of the zooids must not be mistaken for the ground-color. Its pigment cells are located more superficially, and when it is at all thin the ground-color can be seen beneath it (fig. 8). The differences in the ground-color, although extensive, are not usually abrupt, and gradations are encountered. Thus, in the offspring of colony 1 (figs. 1–15) the ground-color of the vigorous adult colonies varied from black (fig. 1) through brown (figs. 7, 11) to yellow (fig. 3) and also to bright brick red, although no representative of this color was drawn in its prime.[1] The colony represented in fig. 14 would probably have assumed a distinct red color later on. It was not quite adult when drawn, and was lost before it became so.

*(b) The Color Markings of Class (b).*—These are almost always present at some period during the life of any colony, and their variations are continuous, all gradations being encountered among the members of the same family.

*(c) The Color Markings of Class (c).*—These, and these alone, exhibit discontinuous variations. Only three color markings of this kind have been found among the members of the families examined. In all three cases these markings consist in the covering or replacement of a limited area of the normal dark pigment by a light one.

---

[1] The comparisons made in this section are only between the normal adult zooids of vigorous colonies; so that all the variations discussed in sections 1, 2, 3*a*, and most of those in 3*b*, are ruled out. Thus, each colony is considered as having only one color—that of its prime.

These color markings are:—

1. The dorsal double bands, extending from cloacal to branchial orifice. These bands were found only in Family II (figs. 16–23) and Family III (figs. 24, 25). The mothers of both families had them well developed. In Family II six of the young colonies became old enough to acquire the adult colors; and of these, two (figs. 17, 19,[1] 23) had the dorsal bands, two had no trace of them, looking like the upper colony in fig. 23, and two had the anterior half of the bands developed (fig. 22).

2. The light-colored coating on the cloacal halves of the zooids (figs. 3, 8, 14). It always extends all the way from cloacal to branchial orifice, but sometimes extends squarely across the zooid (fig. 8) and sometimes is drawn out into a point which touches the branchial orifice. In the case of this marking the discontinuity is not so striking as in the previous one; perhaps because there were a larger number of colonies to examine. It was encountered only in Family I (figs. 1–15). Seventeen colonies were examined, and in only two cases were transitions from colonies possessing the coating to those without it encountered. In one case (figs. 11, 12) the coating was only partially developed; in fact, there is a question whether the marking represented a coating or the two dorsal bands. But this imperfect development was quite constant during the prime of the colony. The other exception was the colony represented in fig. 8. When this colony was in its most flourishing condition its zooids sometimes had the coating as in the figure, sometimes had none, and sometimes presented a streaked intermediate condition. With these two exceptions, the variation was discontinuous. The contrast between the colonies having the coating and those without it was greater than appears in the figures, for it frequently happened that two or more colonies would be exactly alike except for the presence in one of them of

[1] The condition of the dorsal bands in the other figures of this same colony (figs. 18, 20, 21) cannot well be considered as transitions to another type, for they do not represent the usual appearance at that time, but only the extremes represented by a few zooids.

the coating. But as such colonies could be adequately described by saying that they were like such a figure with the exception or addition of the coating, they were not figured.

3. Light coloration of the lower lips of the cloacal orifices (figs. 1, 3, 15). This variation also occurred only in Family I; and it was only in two cases that there was the least doubt whether the colony belonged to the class with black or light colored cloacæ. Often the cloacal marking would be the first to develop, and would be very prominent, while the rest of the markings were still indistinct, as in fig. 15. There were several colonies in which the cloacæ, though distinctly belonging either to the light or dark type, were not very strongly marked, as in fig. 11. But what makes the variation so striking here is the early appearance of the light cloacæ, and the fact, already noticed in connection with the light-colored coatings, that often two colonies may have *exactly* the same color except for the difference in the cloacæ. There is, then, so far as these three characters are concerned, a decided, though not perfect, discontinuous variation. If this variation were usually associated with other characters varying in a perfectly irregular manner, it would perhaps have escaped notice. But an important fact to be noticed in this connection is, that while, in any chance lot of *Botryllus* colonies, it is a rare thing to find two that are exactly alike, this is quite common among members of the same family. Thus, in Family II, in a total of six, there were two pairs of colonies that were exactly alike; and many similar instances were noted in Family I. Now, what makes the discontinuous variation so striking is the circumstance already mentioned, that frequently two colonies are exactly alike except as regards the variable character. This was noticed many times, and is illustrated by fig. 23. When examining variations of this kind, the justice of the contention is impressed upon the writer that there must be something in the germ plasm corresponding, for instance, to the double dorsal bands, and that during development this something

usually either lies entirely dormant, or manifests itself in its completed and typical condition.

## *B.* SPECIFIC CHARACTERS.

The characters that have been used to differentiate the species of the genus *Botryllus* are in the main:—

1. Thickness of the colony, and the ease with which it is detached from its substratum.
2. The size of the systems, and the intervals separating them from each other.
3. The size of the colonies and zooids.
4. The color of zooids and ampullæ.

### 1. THICKNESS OF THE COLONY.

The thickness of the colony is of much value in distinguishing the various genera of the Botryllidæ; but, within the genus *Botryllus*, the comparatively small variations observed were not congenital, nor even constant, for the same colony. The thickness varied in the same colony with its age and environment; and the same must be said of the ease with which the colony is detached. Thus, all the young and vigorous colonies that have plenty of room in which to grow, and a clean substratum, are thin, and are firmly attached to the substratum. The older colonies that are not growing so fast are thicker, even when they have plenty of room in which to spread; and when their area of attachment is limited by competition with other incrusting organisms they are thicker still. The extreme in this direction was seen in a Woods Hole colony which was being encroached upon from all sides by an incrusting bryozoan. Since it could not spread out laterally, it had grown in thickness until it had become a little sphere about one centimeter in diameter.

The ease with which a colony can be detached depends, so far as could be seen, entirely upon external conditions. A firm attachment is only possible when the substratum is

clean, and when the colony has recently grown onto it. Later, worms, crustacea, diatomes, and other organisms establish themselves under the *Botryllus* colony, and help to loosen its attachment. If the substratum is covered with mud and minute animals in the first place, a firm attachment is never established. It is evident, then, that neither the thickness of the colony nor the firmness of its attachment furnish useful diagnostic characters.

### 2. NUMBER OF ZOOIDS IN A SYSTEM.

The number of zooids in a system varies greatly in the same colony at the same time, and also varies with the age of the colony. It may be that there is an inherent tendency in some colonies to have a certain mean number of zooids to a system, but this tendency is not evident at first sight. Lengthy observations and a quantitative treatment would be necessary to demonstrate it. The most obvious variation in the size of the system is found in old colonies where the number of zooids is diminishing. Here, though the number of systems in a given area remains the same, the number of zooids comprising a system is reduced to an average of three or four.

The size of the intervals between systems depends almost entirely upon the rapidity of growth, and the amount of growing room. In vigorous colonies confined in a small space, there is almost no space between the systems, while in colonies that are free to extend in all directions about one-third of the surface is occupied by the systems.

### 3. SIZE OF ZOOIDS AND COLONIES.

The variations in the size of both the colonies and the adult zooids depends, so far as could be seen, entirely upon the vigor of the growth and the age of the colony. In very young colonies, containing only a few zooids, the latter never grow as large as the smallest adult zooids in

the older colonies. But as the colony grows, each succeeding generation of zooids reaches a greater size than the preceding. The maximum is usually reached while the colony is still young, lightly pigmented, and growing vigorously. The edge of the colony is always growing faster than the center; and when the zooids of the same colony differ in size, it is always at the edge that the largest zooids are found. When the colonies have about reached their maximum size, and their color patterns are well developed, but the growth is a little slower, the maximum size of the zooids is somewhat reduced; and, finally, when the colony is old, and the number of zooids decreasing, the latter never grow much larger than when the colony was very young (fig. 16). Figures 17 to 21, all drawn to the same scale, show some of the variations in the size of the adult zooids of the same colony.

### 4. Colors of Zooids and Ampullæ.

The colors of the zooids and ampullæ have been used so much in distinguishing the described species of *Botryllus* that the other characters just discussed are of very little importance when compared with them. Almost every described species has been partially, and many entirely, based upon color characters. The frequency with which these characters have been used for diagnostic purposes undoubtedly depends upon the immense variation to which they are subject. This is so great that in any lot of *Botryllus* indiscriminately collected it is usually somewhat difficult to find two with exactly the same colors. The large extent of this variation has often been emphasized. In fact, several of the authors that have described species of *Botryllus* have expressed doubt as to whether it was really species they were describing and not merely variations.

The evidence that is here offered as to whether the variations in color furnish characters that are of value in separating species depends upon the observation of the three families of colonies mentioned (pp. 139, 143).

Differences in color were observed as follows:—

*(a)* In the same zooid at different ages.

*(b)* In the same colony, resulting from age, vigor of growth, and changes of environment.

*(c)* Between the various colonies derived from the same parent, and subjected to the same external conditions.

In the previous section the nature of the color variation, as such, has been considered. Here we are concerned only with the problem whether it is permissible to use differences in color in *Botryllus* as diagnostic characters. Certainly differences belonging to any of the three classes mentioned above may be affirmed to be of no specific value; and accordingly the plan will be to compare the colors of the zooids observed at different times in the same colony, and in brother and sister colonies, with the colors of the various species of *Botryllus* described.

Before beginning this comparison, however, it should be again pointed out that only a small part of the variations obtained are recorded in the figures. Many of the colonies died or were killed by some of their many enemies before they could be figured. The color also changed so frequently that it was impossible to record all the variations. Furthermore, the zooids figured were not selected with a view to their comparison with described species, but rather to record the amount of variation, and therefore many zooids that had very nearly the same color as some of the described species were not figured.

In spite of these disadvantages, however, the figures of the members of these three families show quite a close approximation to seven described species.[1] In Family I there are:—

*Botryllus aurolineatus* GIARD, var. *ι* DELLA VALLE, 1877, p. 28.

Figure 8 corresponds closely to the description, except that the coating of white may extend too far anteriorly,

[1] Unfortunately, the original figures have not been accurately reproduced in all cases, and consequently the originals will be gladly sent to any one especially interested in the subject. The extent of the variation, however, is quite accurately represented.

and that the lower lip of the cloacal orifices is colored black instead of yellow. In the same family, however, there were several colonies very similar to fig. 8 in every way except that they had no white coating and the lower edges of the cloacal orifices were yellow.

*Botryllus marionis* GIARD, 1872, p. 630, Pl. XXX, figs. 1 and 2:

Figure 8 without the white coating would have nearly the color of a form intermediate between Giard's varieties *α* and *β*. Figure 1 represents a colony that had much resemblance to variety *α*, especially when, as often happened, the general tone became more brown, and the anterior part of the zooids was more yellow.

*Botryllus calendula* GIARD, 1872, p. 623, Pl. XXVII, figs. 1 and 2:

Figure 2 resembles Giard's description and figures closely. Even if my figure 2 and Giard's figures had been taken from the same generation of zooids in the same colony, the likeness could not have been absolute; for Giard's figures show only degenerating zooids and young zooids that have not yet united to form systems, while fig. 2 in this paper represents adult zooids. The absence of distinct color markings in both is quite noticeable, especially as it is not common. The condition represented in fig. 2 was produced by the unfavorable conditions of the aquarium in a colony normally resembling fig. 1, but with more of the yellowish color, like fig. 8. The fact that in Giard's figures the younger generation of zooids is nowhere more numerous than the older, points toward the conclusion that here, too, the conditions were unfavorable.

*Botryllus rubens* ALDER & HANCOCK (ALDER, 1848, p. 204).

Figures 2, 4, and 5 agree well with the description, fig. 4 especially so.

Among the variations of Family I, then, we have zooids whose colors correspond to four described species. Family II

(figs. 16–23) furnishes variations corresponding to the following species:—

*Botryllus gemmeus* SAVIGNY, 1816, p. 203.

Figure 21 agrees quite well with the description, except in that the dorsal lines are not complete. At the time of drawing, however, most of the zooids of the same colony had the dorsal bands complete.

*Botryllus morio* GIARD, 1872, p. 629, Pl. XXX, figs. 8, 9.

Figure 23 (white banded zooids) agrees well with Giard's description; and the mother colony (fig. 16) agreed still better a few generations before the drawing was made. At the time when it was drawn, the colony was rapidly degenerating, and the two dorsal bands had become fused into one.

*Botryllus morio* var. δ DELLA VALLE, 1877, p. 25.

Figure 23 (zooids without white bands) agrees almost perfectly with the description; and fig. 10 of Family I also agrees well, but here the lines causing the reticulation are not produced entirely by an absence of pigment, but have a pigment of their own. Since both these figures agree so well with Della Valle's description, we are justified in uniting the families I and II, and saying that all of the described species just enumerated should be united into one species, as the color variations represented by them are found among the members of two families, the variations of which overlap.[1]

Summarizing the results of this comparison, then, *it has been proved that B. aurolineatus var. ι, B. marionis, B. calendula, and B. rubens must undoubtedly be united into one species, and B. gemmeus and B. morio into another; and furthermore, that there is ample evidence for uniting all the six species mentioned into one.*

[1] For other cases in which the variations in the two families overlap, compare fig. 10 with fig. 22; and figs. 11 and 12, both of the same colony, with figs. 18 and 19, also drawn from one colony. As the zooids of each of these last mentioned pairs of figures belonged to the same colony, all gradations between the two conditions were observed, and, had that been the object, it would have been easy to select zooids from different families resembling each other still more closely.

But in examining the character of the variations presented by the three families from a systematic point of view, even more important conclusions may be drawn. Although as regards described species they may be applied to six species only, as regards the kind of color characters that can be admitted to have any value as diagnostic characters they have a much wider bearing. Thus none of the following color characters are of any value in differentiating species or even varieties:—

1. *Color of the ampullæ*, for it varies much in the same colony at different times and in different regions at the same time. Thus, in the colony whose zooids are represented in figs. 26 and 27 the ampullæ near the green zooid were of the same green as the zooid, while those near the other were transparent with a very light green tinge. The color of the ampullæ varies regularly with the age of the colony. At first they are transparent, then light grayish, yellowish, or greenish, while in old age and unfavorable conditions dark browns and black usually predominate. The dark pigment, however, is often mixed with opaque white, which may supplant the yellow pigment present at an earlier period.

2. *The general tone, or ground-color, of the zooids* is of no value, for it may vary in different parts of the same colony (figs. 26, 27) or in the colony at different times (figs. 11, 12, 17–21), or still more in different colonies of the same family.

3. *The presence of conspicuous markings*, such as the double dorsal bands, light colored lower lip of the cloacal orifice, and light coating covering the posterior part of the zooid is of no value, for these may be conspicuously developed, entirely absent, or partially developed in colonies of the same family (Family I, figs. 1–15; Family II, figs. 16–23).

4. *The color or shape of such markings* is valueless, for they vary in the same colony even at the same time. The

shape of these markings is usually very variable; for example, at the time when figs. 20 and 21 were drawn many of the zooids in the colony had complete dorsal bands. Figures 18 and 19 offer another example. The color, however, is often remarkably constant. For instance, the white color of the dorsal bands remains constant for all the members of Family II. In the colony whose zooids are represented in fig. 8, however, the mantle later assumed a lemon-yellow and in some zooids even a decided orange color.

5. *The presence of a color pattern* developed about the branchial orifice (figs. 1, 8, 11, 26, 27) or on other parts of the zooid (figs. 10, 21, 22) is of no value, for this varies greatly in the different colonies of a family or even in the same colony at different periods. Patterns of this kind, that depend upon the unequal distribution of the two kinds of pigment making up the ground-color (figs. 8, 11, 21, 23), were always seen to disappear when the colony was placed in unfavorable conditions (figs. 2, 4) or lost its vigor through age (fig. 16).

The list given includes about all of the possible color characters used for diagnostic purposes; and it points inevitably to the conclusion that *in Botryllus, as it occurs in Europe and the Atlantic Coast of North America,*[1] *color characters cannot be used for separating species; and that, therefore, since none of the described species have been based upon morphological characters, there is no valid reason for recognizing more than the single species, B. schlosseri (Pallas, 1766, pp. 355–356) Savigny (1816).*

It might be thought that *B. gouldii* Verrill (1871, p. 211) of the Atlantic Coast of North America should be excepted in this general lumping of species; but so far as can be seen at present, there is no ground for making an exception, for *Botryllus* at Woods Hole and at Newport exactly

[1] The species on the Pacific Coast of North America (*B. magnus* Ritter (Proc. Washington Acad. Sci., Vol. III, p. 255), and an undescribed species) do not show any color variation, and appear structurally distinct from *B. schlosseri*.

resembles *Botryllus* at Naples. In the main, even the same color variations are met with; but their relative commonness differs somewhat in the three localities. Judging from the results here given, it would seem to be perfectly possible, starting with a small number of colonies of nearly the same color, and preserving their offspring, to raise in the course of a few generations all of the color varieties found in any locality.

## IV. FUSION OF COLONIES.

By fusion is meant the complete union of two originally separate individuals into a single individual, accomplished by means of simple growth without any operative procedure. It has frequently been called concrescence by French writers; but, in view of the wide use of this term in embryological literature, fusion appears to be a better word. The process has often been mentioned in zoological and botanical literature; but it is only rarely that adequate proof of its occurrence has been offered. Thus, for the Tunicates, although a comparatively extensive literature on this subject has sprung up, it is only the last paper dealing with it (Pizon, 1900) that has recorded an observation which proves the fusion of colonies to be a fact. One circumstance that has tended to obscure the subject has been the lack of clear distinction between the fusion of colonies derived from separate embryozooids and the fusion of zooids in the same colony. The last question does not concern us here; it is merely a drawing closer of the bonds which have already succeeded in keeping the zooids in organic connection so as to form a colony. The fusion of colonies, however, is of deeper significance, as it gives us some insight into the forces that determine competition between neighboring colonies, and the question of individuality.

The question of the fusion of ascidian colonies was first raised by Gegenbaur (1862, p. 166), who believed it probable that in *Diplosoma (Didemnum) gelatinosum* many

larvæ were not extruded, but metamorphosed within the colony and added to the number of its zooids. Later, Della Valle (1881, p. 476) discovered the budding in the adult zooids, and gave other evidence against the fusion of the embryozooids with the colony which produced them. Lahille (1890, pp. 122, 134) supports Gegenbaur, but gives no conclusive evidence.

Seeliger (1898, p. 175) states for the Clavelinidæ that larvæ may settle on the mother colony, and fuse with it; but does not give any evidence to support this view.

In families like the Diplosomidæ and Clavelinidæ, where individual differences are not large, it is ordinarily impossible to detect whether any colony is composed of several united colonies or not. Among the Botryllidæ, on the other hand, where the individual variation is very great, it might be expected that differences in color would enable one to determine at a glance whether a fusion of two colonies had occurred. But for the Botryllidæ almost all the evidence heretofore given is also unsatisfactory. Thus Giard (1872, p. 590) stated that adjacent colonies fused; but offered no evidence to substantiate his statement. Still his belief in the process was so strong that he used the absence of fusion in adjacent colonies as a criterion of the specific distinctness of the two forms. Pizon (1892–1893, pp. 196–198; 200–202) says that fusion between adjacent embryozooids frequently occurs, the test first fusing and then the cloacæ approaching each other to form the common cloacal orifice of the first system. Later he stated that on five or six occasions he has found agglomerations of young embryozooids of Botrylloides, which were partially fused together. Sections through the mass failed in many cases to show any line of separation between the test of adjacent zooids, though in other cases they did. He believes that from these masses single colonies are formed; but offers no further evidence.

In his last paper, however, Pizon (1900, pp. 15–16, 51–52, Pl. IV) describes and figures an undoubted case of fusion in two embryozooids of *Botrylloides rubrum*. The

two zooids are enclosed in a common test, two notches only remaining to indicate the former line of separation. Certain of the blood-vessels have also fused, forming a single vascular system for the two zooids.

The writer's investigations on this subject were completed about eight months before the publication of the paper of Pizon, above referred to, and were performed with unrelated adult colonies, with pieces of the same colony, with unrelated, and sister and brother embryozooids, and with the adult colonies developed from these related embryozooids.

### 1. FUSION IN UNRELATED ADULT COLONIES.

The fact that ordinarily colonies do not fuse with one another is satisfactorily demonstrated by a mere inspection of any lot of colonies, especially such a lot as may be obtained from the Eel-pond at Woods Hole. At this place the writer has examined hundreds of pairs of colonies that were closely pressed against each other, but has never seen any evidence of fusing. The colonies are everywhere distinct, and their zooids always of the same color. At Naples, as already stated, zooids of different colors have been seen in the same colony; but this difference is not due to the fusion of colonies. It may be confidently stated, then, that: *In general, unrelated colonies, such as are found next to each other in nature, do not fuse, but struggle with each other for a substratum to grow upon.*

### 2. FUSION BETWEEN ISOLATED PIECES OF THE SAME COLONY.

If a colony is cut into several pieces, the wounds heal in a few minutes. In a day such pieces cannot be distinguished from ordinary colonies. If now these pieces are allowed to grow naturally toward each other, *they will not compete, but fuse completely*, both test and vessels of one piece becoming united with the same organs in the other. This fusion was observed very many times, and in no case did it fail to take

place where there was an opportunity for it. In four cases the isolated pieces of Woods Hole colonies were watched carefully day by day, and the exact place of fusion noted. Colonies which were well attached to a slide were taken, the greater portion of them removed, and the pieces, separated by intervals of a half or one centimeter, allowed to grow towards each other. They were examined every day.

In the first case, the fusion took place on the sixth, in the second and third cases on the tenth, and in the last case on the fifteenth day after the separation.

In the first two cases, the isolated pieces developed at the same rate; so that at the time of fusion the zooids in both pieces were in about the same phase.

In the third case, embryos developed in both pieces, but at different rates; so that, at the time of fusion, the larvæ had all been extruded in one piece, and the zooids which contained them had entirely disappeared, while in the other some of the old zooids with larvæ remained.

In the fourth case, embryos developed in only one of the pieces, and its budding was retarded in consequence; so that the change of zooids took place about a day after it had been completed in the other piece.

It is thus seen that in order that a fusion of two pieces of one colony should take place, it is not necessary for the two pieces to contain zooids of the same age or in the same phase of development.

### 3. GRAFTING IN BOTRYLLUS AND BOTRYLLOIDES.

After fusion had once been obtained between pieces of the same colony, it was thought that although ordinarily adjacent colonies would not fuse, still a union could be obtained by means of grafting. This process was tried on many colonies of Naples *Botryllus*, but was never successful, even with colonies of the same color. In spite of sewing and tying the colonies together, a vascular union was never formed, though occasionally the tests of the two colonies adhered slightly to one another. There seemed

to be some active antagonism between the colonies, which prevented a union even when two cut surfaces were placed in contact.

In the case of *Botrylloides*, however, a better success was encountered. Only two colonies of *B. gascoi* were at the writer's disposal; but one of these had been collected a week earlier than the other, thus increasing the probability that they were not parts of the same colony. A union of these two individuals was easily obtained by grafting. The vessels in the two pieces joined with each other, and the zooids from both helped to form the same system. To test the reason for the union in this case, other pieces from the same two colonies were taken, and allowed to grow toward each other naturally. When they met the two colonies fused, thus showing that the reason that the graft took in this case was not because of a particularly favorable operation, but because there was no antagonism between the two colonies.

Similar results were encountered with *Botrylloides rubrum*. There was no difficulty in obtaining a union of two colonies either by grafting or growing towards one another. Although a fusion was obtained in only three cases, still it occurred in the majority of the trials, and was also encountered where the growth was vigorous enough to lead one to expect it. Therefore in spite of the limited number of observations, the conclusion seems justified that: *On the whole, neighboring Botrylloides colonies behave very differently towards each other from Botryllus colonies.*

A hint as to the cause of this difference may be found in the character of the variation in the two genera; for, while in *Botryllus* the variation could hardly be greater, in *Botrylloides* it is quite limited. All of the six or seven colonies of *Botrylloides gascoi* seen, had, except when æstivating,[1] exactly the same color pattern and practically the same color. Fully a hundred colonies of *Botrylloides rubrum* were examined, and no variation at all comparable to that in *Botryllus* encountered. The color pattern varied but little, and the color only from a yellowish to a deep

[1] An account of this æstivation is awaiting publication elsewhere.

pure red. *Thus it seems that, in Botrylloides, adjacent colonies often fuse and do not compete with each other because they are not so different from one another as the colonies of Botryllus.*

### 4. FUSION OF RELATED BOTRYLLUS COLONIES.

In order to still further test the question of fusion in *Botryllus*, observations were made on colonies developed from larvæ extruded by the same mother colony. It was found that some of these colonies would fuse, but others would not, although the conditions were the same in both cases.

The criterion employed, here as elsewhere, for a fusion is the establishment of a common vascular system. Thus, no colonies were recorded as having fused unless the blood could be distinctly seen passing from one to the other in the living colonies. In this way a fusion was observed between twenty-nine pairs of related colonies; while but eighteen pairs of related colonies were observed which were in contact long enough to have fused without doing so.

Now there can be no doubt that brother colonies are more similar, both so far as color and other characters are concerned, than unrelated colonies. Hence, from the observations on *Botryllus* we have still further confirmation of the conclusion reached in the preceding section; that *it is some similarity in the two colonies which determines that they shall fuse and not compete.*[1] But unfortunately it could not be determined wherein this similarity consisted. It is not similarity in color which decides the matter, in spite of the small color variation in *Botrylloides*; for *Botryllus* colonies with the same and with very dissimilar colors were seen to fuse, and the same variations were observed among the members of the pairs that had ample opportunity to fuse but did not do so. By referring to the figures the amount of these variations may be seen. Among others, the pairs of colonies

[1] Jensen (Arch. gesam. Physiol., Bd. LXII) has noted fusion of *Orbitolites* under similar circumstances; pieces of the same individual, and young animals from the same mother fusing, while under other circumstances individuals refuse to fuse.

represented by the following figures fused: fig. 23; figs. 1 and 2, but at that time the colony represented in fig. 2 had the appearance of fig. 8 without the coating; fig. 3 and a colony much like it, except that it had black cloacal orifices; figs. 1 and 3; figs. 8 and 9, but at that time the latter colony looked more like fig. 8 without the white coating but with whitish cloacal orifices; fig. 8 and another colony of nearly the same, and sometimes of exactly the same color; fig. 9 and another colony of exactly the same color; figs. 10 and 11; figs. 14 and 15. Similarly, the colonies represented by the following pairs of figures did not fuse though they had ample opportunity: figs. 9 and 11; figs. 10 and 14.

The fusion is not entirely determined by vigor of growth, though of course the colonies must be increasing in size; for the absence of fusion between two very vigorous colonies and also between one very vigorous and one rather weak colony was observed, though the weak colony might later fuse with another one. Nor does the presence of sexual reproduction, or the fact that in one colony the zooids are full grown, while in the other they are ready to die, influence the process. It cannot even be said that colonies that have been in contact for thirty-three days without fusing would not have fused if left in contact longer; for two colonies that were in contact for twenty-eight days without fusing fused on the twenty-ninth day. But it is certain that some pairs fuse very much more easily than others, and also very probable that in many pairs fusion would never occur, no matter how long the colonies remained in contact.

The general conclusion mentioned above, *that it is the degree of similarity between isolated colonies and not their separate existence that determines whether they shall compete with each other for a substratum to grow on or whether they shall fuse*, is not without some general importance. We are usually in the habit of considering that competition depends solely upon the existence of several separate individuals, living in close proximity to one another; and that it is strongest between those individuals or species whose habits and needs are most similar. But in some *communities* of

animals, such as are found among the ants and bees, inherited instincts or reflexes have brought about a state of affairs in which the individuals do not compete, but co-operate with each other. The community then becomes the competing unit, and it may even happen that communities may combine to form competing units of a still higher order. In the case of trusts and labor unions among men, intelligent co-operation has produced the same result, abolishing, to a certain extent, competition between the most similar competing units, and producing units of a higher order.

Among the fusing colonies of *Botryllus* we have a similar formation of a higher competing unit, accomplished by the simplest of all means—organic union; and, from the analogy of the other cases mentioned, it is especially interesting that this combination is only possible between the most similar units.

### 5. Details of the Process of Fusion.

Fusion has only been observed when both colonies were of the same age. But it apparently makes no difference what this age is. Fusion was seen to occur between embryozooids, young colonies of all ages, and adult colonies nearly three months old. In all cases the fusion took place in the same way, except that when embryozooids fused there was no tendency towards an aggregation of the zooids into one system (text-fig. 1).

The manner in which the fusion occurs brings us a step further in determining wherein the mutual compatibility or antagonism depends. The final problem, however, remains unsolved. In the first place, it seems necessary that *a certain amount of pressure must exist between two colonies before they will fuse.* The fact mentioned above, that mere contact of the colonies is not sufficient, but that they must be growing towards each other if they are to fuse, points in this direction. Further evidence was obtained by a series of observations on isolated pieces of the same colony. These ordinarily fuse with extreme ease. In three of four pairs of pieces examined at one time the fusion occurred

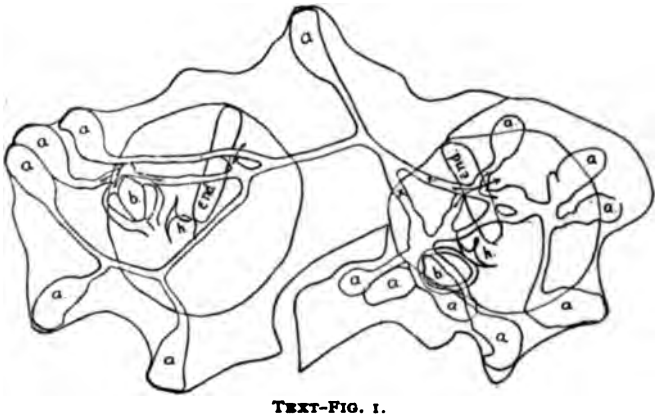
after the pieces had been in contact for less than a day. In the fourth pair, however, the edge of one piece was considerably thicker than that of the other, and contained more ampullæ; so that after the edges met, the thicker edge was pushed over the thinner one instead of against it. During the next day, however, the number of ampullæ in both edges increased, and a rearrangement took place, when both edges were found squarely pressed against each other. On the day following, fusion had been accomplished. This case brings out more strongly the fact that *there is a certain amount of resistance that is overcome by the mutual pressure of the edges before the fusion can take place.*

It might be supposed that this pressure was needed to bring the ampullæ into such close contact that their pulsations[1] would not interfere with their union. But this does not appear to be the case; for in spite of much searching, it was impossible to find two fused ampullæ. The reason for this absence of fusion may perhaps be found in the pulsations of these organs; but it is probable that it must be sought in the mutual repulsion of the ampullæ; for, even in the same colony they do not fuse, so far as is known, and in adjacent colonies they are often seen so closely appressed that no intervening substance can be detected, and their pulsations do not materially decrease the area in contact; but still no fusion occurs.

The first change that is observed in two colonies that are about to fuse is that some of the ampullæ from one or both colonies penetrate the test of the other. These grow past

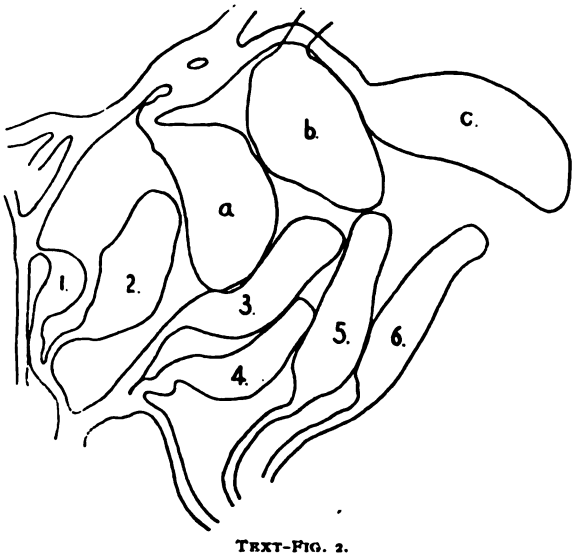
[1] Pizon (1900, p. 64) in discussing the results in the writer's paper on the contractile function of the vascular ampullæ (Bancroft, 1899) comes to the conclusion that other more convincing facts must be brought forward before it can be admitted that the walls of the ampullæ have the power of contractility. In the main, this would be true for the facts which Pizon discusses; for, although offering strong evidence for the independent contractility of the ampullæ, they do not prove it beyond doubt. But the writer cannot agree with the illustrious French ascidiologist that the power of contraction of the ampullæ is left at all in doubt if the full evidence offered in the paper mentioned is taken into consideration. He does not give more than a passing mention to the principal fact upon which this power was based, and apparently does not consider it in arriving at his conclusion,—the fact that the pulsations of the ampullæ continue after all the buds and zooids of the colony have been removed. To the writer this is absolutely convincing, and it seems that no stronger evidence could be adduced.

the ampullæ of the opposing colonies until they come in contact with one of its blood-vessels. Then the walls of the ampullæ and the vessel fuse, their lumina become continuous, and the common vascular system is established. Several stages in this process are shown in text-figs. 1 to 3.




TEXT-FIG. 1.

Fig. 1. Two embryozooids of Family II that have fused, from below. *a.*, ampullæ; *b.*, bud; *end.*, endostyle; *h.*, heart; *x x*, the pedicels of two ampullæ of the left hand zooid that have fused with the vessels of the right hand zooid; the arrows indicate the places where blood was seen to enter the zooids from the vessels in the test. Drawn with the camera; x 43.




TEXT-FIG. 2.

Fig. 2. The ampullæ and connected vessels of two colonies that are undergoing fusion. The ampullæ of one colony are lettered, and those of the other are numbered. Camera; x 43.

TEXT-FIG. 3.

Fig. 3. The same as fig. 2 but seventeen hours later. Letters and figures refer to the same ampullæ. The arrow indicates a place where blood was seen to pass from the stalk of ampulla 5 into ampulla *a*. The case of ampulla *a* shows better than any other how an ampulla may be in contact with other ampullæ for a long time without fusing but fuses with a vessel as soon as it meets it. On the left of figs. 2 and 3 several stages in the process of the reduction of fused ampullæ to make normal blood-vessels may be observed. Camera; x 43.

It seems probable that the tests of the two colonies must have fused before the ampullæ can pass the boundary of their own colony; but the test is so transparent that it very frequently happens that no boundary line can be detected between two adjacent colonies that are not in the process of fusing. After two colonies have become thoroughly united, however, one is not able to see any boundary line between them. It is therefore certain that *fusion does occur between the tests of two colonies.*

### 6. PHYSIOLOGICAL CHARACTERISTICS OF FUSED COLONIES.

We have seen that so far as several morphological characters are concerned, fused colonies are exactly the same as a single colony. They are united in a single mass, they are contained in the same test, and they have a single vascular system. But, associated with these morphological

characters, there is a series of physiological characters of equal importance. These are the force regulating the size of the systems, and the correlation in growth and reproduction of the zooids.

### *(a) Force Controlling the Systems.*

In every *Botryllus* colony the zooids are arranged in systems of from four to twelve zooids around a common cloacal orifice. The manner in which these systems are formed was first clearly described by Krohn (1869, 1869*a*), although Giard (1872), Jourdain (1886), and Pizon (1892–1893, 1899, 1900) have not given him the credit he deserves. From his account, from that of Pizon (1899), as well as from the writer's own observations, it is evident that the systems persist no longer than one generation of zooids. When the new generation first appears, each zooid has a separate cloacal as well as branchial orifice, and the zooids are irregularly arranged. Soon, however, they group themselves into systems, and the cloacal orifices fuse to form the common cloacal opening.

There is evidently some attractive or repulsive "force," the nature of which is entirely unknown, which in *Botryllus* causes any number of adjacent zooids up to about twelve to form one system, but which causes a greater number of adjacent zooids to break up into two or more systems. Now the question arises, is this force of such a nature that it will tend to cause zooids derived from different colonies to help form the same system? In only one undoubted case[1] (fig. 23)

[1] In one case three colonies were dredged, one of which contained zooids of two colors, sometimes present in the same system. It was concluded from the evidence at hand that these colonies had all been derived from the same mother colony, and that the colony with the two kinds of zooids had been derived from the fusion of two sister colonies. As these colonies form the only exception to the general statement made above, that in *Botryllus* colonies collected by ordinary methods, and, therefore, probably unrelated, do not fuse, the evidence should be given. The three colonies came up in the same haul of the dredge, and repeated dredging in the same locality failed to bring up any more. The writer was immediately struck by the similarity of coloration (although at that time not knowing that sister colonies sometimes have the same color, or that they will fuse). Two of the colonies had exactly the same color and color pattern, and the third was exactly like these two, except that some of its zooids had a light coating of white upon their cloacal ends. A reference to the section on variation will show that it is just this kind of variation which is eminently characteristic of sister colonies. Furthermore, when grafted together or allowed to approach each other by growth, they fused. Hence, in all respects they behaved like sister colonies, and the colony containing the two kinds of zooids was probably derived from two fused sister colonies.

was such a composite system observed. But one would not expect to find it frequently; for in a composite colony the two fused colonies would in general occupy different regions. Furthermore, since they were all growing rapidly the new systems would usually be formed from the buds of zooids which had belonged to the same system, and it would happen but occasionally that the two systems were so close together that, when the next generation was developed, zooids from both systems would come together to form a single one. Accordingly, the negative evidence is not weighty, and one must therefore conclude that *when two colonies have fused, the two kinds of zooids behave toward each other, so far as the formation of systems is concerned, exactly as if they had always belonged to the same colony.*

*(b) Correlation in Growth and Reproduction.*

This is subject to minor variations, but in the main it is remarkably constant. It has long been known that all of the zooids present in the same colony are not only of the same generation, but in the same stage of development. They all die together, and all develop their buds at about the same rate. If any of them contain ova or embryos, usually all of them do; and all extrude the larvæ at about the same time. It was found that when two pieces of the same colony or from two colonies, whose zooids were not in the same phase of development, fused, these differences were invariably equalized. In one case, however, where the change from one generation of zooids to the next took place about four days later in one colony than in the other, the equalization was not accomplished before twenty days. This equalization was repeatedly observed, and in most cases was accomplished much more quickly. Particular attention was not devoted to sexual reproduction in fused colonies; but no instance was noted in which one part of a fused colony contained embryos while the other did not. Thus it is seen that in physiological as well as morphological respects fused colonies act exactly like a single colony. There is, however, one difference between the two. In the fused colonies

the zooids may differ in color; and not the slightest tendency toward an equalization of this difference could be detected. The zooids changed in color in the way indicated in the section on variation, but these changes did not tend to make the colors of the fused colonies more similar. The conclusion, then, of this study of fusion is, that *it is only between colonies which resemble one another more closely than usual that fusion takes place; and that after the fusion has become fully established, the two colonies are in every respect like a single colony, except that the zooids may be of different colors.*

## V. THE QUESTION OF THE INDIVIDUAL.

All multicellular organisms are to a certain extent colonies and also to a certain extent individuals. In how far they should be considered as mere aggregations or as single individuals is still one of the most interesting and important biological questions. The same question may be asked concerning those looser aggregations of units of a higher order, commonly called colonies; and it is in cases of this kind that we have more hope of determining the essential characters of the individual, on account of the greater simplicity of the problem. *Botryllus* is a colony of a simple type, composed of a single kind of zooids that are but loosely aggregated together. On this account a discussion of the results arrived at, with reference to the question of the individual, will probably prove of some benefit, at least in pointing out the most profitable direction for future research, even if no very positive results have been attained.

This question, then, presents itself in two forms:—

(1) Should two fused colonies or the separated parts of a single colony be considered as one or two individuals?

(2) To what extent should a *Botryllus* colony be considered as a single individual and not as an aggregation of zooids? What characters and activities does it possess that cannot be considered as the sum of the characters and activities of its zooids?

The first question is a rather barren one, as it is in the main a matter of words, and must be answered differently

according to the criterion of individuality adopted. But it does serve to emphasize the justice of Huxley's (1851) contention, that the zoological individual is "The sum of the phenomena successively manifested by, and proceeding from, a single ovum, whether these phenomena be invariably collocated in one point of space or distributed over many."

This conception was arrived at from the embryological and comparative zoological point of view, as the only means of homologizing the various colonies and pseudo-individuals found among the invertebrata with what we have been accustomed to call the individual among the mammals. It is best spoken of as the *biological individual.*

But the above conception of the biological individual does not include all of the attributes of what we usually mean by an individual. We may still have the *morphological and physiological individual*—an individual localized in a single mass and functioning as a coördinated whole. Both of these conceptions are united in the individual as seen among mammals; but they may be separated, and when this is the case, which is the more essential? Although this question must always remain more or less a matter of opinion, these observations on *Botryllus* show that the conception of the biological individual is more than a mere generalization from embryological and comparative data. For, in this case, the isolated pieces of the biological individual always retain a latent physiological individuality, by means of which they can recognize each other (so to speak) and thus coöperate instead of competing with each other when they are again brought into contact. Ordinarily there is no such compatibility between *different* biological individuals. The fact that sometimes, however, fusion is observed between related biological individuals does detract somewhat from the value of this argument, and also shows that since two biological individuals may form a single physiological one, under perfectly natural circumstances, it is difficult to apply the usual conception of the individual to the lower animals.

To pass on to the second question, namely, To what extent should a *Botryllus* colony be considered as a single

individual and not as an aggregation of zooids; in other words, what characters has it that cannot be considered as the sum of the characters of its zooids?

This question is obviously very different from the first one. It deals with the morphological and physiological individual, and is not concerned with names but with the extent to which the parts have merged their individuality into that of the whole which they compose.

As indicated above, the individuality of the *Botryllus* colony may be spoken of as manifested in both a morphological and a physiological way, though it must not be forgotten that every character can be considered from a morphological or physiological point of view.

The *morphological characters* are:—

1. Separate localized existence.
2. Investment of the zooids in a common test.
3. Presence of a common vascular system.
4. Characteristic and comparatively constant colors of the zooids.

The *physiological characters* are:—

1. The quality determining whether the colony shall fuse or compete with a neighboring one.
2. The force regulating the formation and size of the systems (see p. 173).
3. The coördination in the growth and reproduction of the zooids.
4. The "force" causing the limited existence of the zooids, which results in the fact that certain morphological elements of the colony, such as the blood-vessels and even the ova[1] in the zooids themselves, have a much longer life than the zooids.

Of the *morphological characters* only the last, and that in a rather doubtful manner, can in any sense be considered

[1] It has been shown by Della Valle (1881) that the ova do not complete their development in the zooid in which they originate but migrate bodily to the buds developed by this blastozooid. The writer has been able to confirm this observation on living material; the same ova which on one day were seen in the mother zooid, on the next day were seen to be absent from this zooid and present within the buds which it had developed.

as the summation of the characters of the zooids. Morphologically the colony is not the sum of its zooids, for:—

1. The colony consists of zooids plus the test and the common vascular system.

2. The test is derived in part from the zooids, but probably its major portion is secreted by the ampullæ of the vessels.

3. The common vascular system is not a derivative of the zooids but of the larva. From the first the young colony may be separated into embryozooid and the vessels with their ampullæ. And, though some vessels are derived from the zooids, most of them are developed directly from the vessels of the larva.

The third of the *physiological characters*, the coördination in the growth and reproduction of the zooids, is also, in great measure, if not entirely, dependent upon the common vascular system; for it disappears when a colony is cut in pieces. Thus, it is seen that four of the eight characters which distinguish the colony as a single individual are intimately associated with the common vascular system. That is, they are *the result of the union of the parts into a common mass, and are not dependent upon the common origin of the parts*. This is proven by the fact that they are all true of the composite individual formed by means of fusion. They can in no sense be considered as the summation of the characters of the zooids, but pertain to the colony as a whole.

The other characters, however, the constant color markings of the zooids, the quality of the colony determining fusion, and the system-forming force, apparently do not depend upon the union of the parts into a common mass, but do depend upon their common origin. They are, so far as can be told, not changed in any colony by its fusion with another one. It is, however, only as regards the color of the zooids that we could expect to detect any influence of one part of a composite colony on the other. Any similar influence of one part on another affecting the normal size

of the systems, or determining that part of the composite colony would behave differently so far as fusion is concerned toward a third colony from what it did before it became a part of the composite colony, are such difficult questions that a more extended series of observations would be needed to answer them.

But although these characters appear to be the same throughout the whole extent of the colony on account of the common origin of the whole from a single larva, it does not necessarily follow that so far as these characters are concerned the colony is merely the sum of its component zooids. It is only in the case of characters associated solely with the zooids that this conclusion may be drawn. Thus it is evident in the case of the fourth morphological character, that the colony possesses zooids of a constant color, because all the zooids have the same color, and that hence, in this respect, the colony is merely the sum of its zooids. The same may be said of the fourth physiological character, the force causing the short life of the zooids; and to a certain extent of the second physiological character, the system-forming force, though in this case the constant size of the systems may possibly be partially due to something outside of the zooids, such as some specific chemical substance in the test.

The first physiological character — the quality which determines fusion—probably does not depend upon anything resident within the zooids, but is concerned with the test and the blood-vessels; for, as we have seen, the initial step of the fusion depends only upon these two parts of the colony. But so little is known about this character, and in fact about the second and fourth physiological characters as well, that nothing definite can be said about the parts of the colony in which they reside.

To sum up, then, it is seen that, of the eight characters determining the individuality of the colony as a whole, five are not intimately associated with the zooids, and hence cannot be considered as the sum of the characters resident in the zooids; these are:—

*Morphological Characters.*

1. Separate localized existence.
2. Investment of the zooids in a common test.
3. Presence of a common vascular system.

*Physiological Characters.*

1. The quality determining whether the colony shall fuse or compete with a neighboring one.
3. The coördination in the growth and reproduction of the zooids.

On the other hand, three of the characters are intimately associated with the zooids, and hence these characters of the colony must be considered as due to the summation of the characters resident within the zooids; these are:—

*Morphological Characters.*

4. Characteristic and comparatively constant colors of the zooids.

*Physiological Characters.*

2. The force regulating the formation and size of the systems (?).
4. The character causing the short life of the zooids (?).

The answer, then, to the second question, concerning the individuality of the *Botryllus* colony, is that ***on the whole it must be considered as a single individual and not as an aggregation of zooids***, although certain of the individual characters differentiating one colony from another must be considered, merely as the summation of these same characters resident within the zooids.

Furthermore, it is to be noted that by means of fusion composite individuals may be formed which have all the characteristics of the normal colony, except that the colors of the zooids in the different parts of the composite colony are usually different.

It is seen that by the mere union of the two colonies to form a single one, we obtain something more than the sum of the two colonies. We obtain a single individual,—an individual of a higher order, in which the metabolism and reproduction of all the zooids is strictly coördinated in a way which was not the case before fusion.

## VI. APPENDIX.

Pizon (1900) has devoted considerable space to the consideration of the phenomenon of the decrease in the size of the ampullæ and their pedicels, and its cause. His principal conclusion is, "ces ampoules, d'abord très volumineuses et longuement pédiculées dans les premiers stades, diminuent progressivement pour prendre des dimensions définitives beaucoup plus restreintes chez les colonies un peu plus âgées." The writer has seen this diminution occurring much as described by Pizon, but only in the case of colonies kept in aquaria. It is certain that this progressive decrease in the size of the ampullæ and their stalks from the embryozooid through the next few generations is not a process that takes place normally in a natural environment, but is due to the unfavorable conditions in the aquarium. There is no doubt that, even in their natural habitat, the ampullæ regularly decrease in size during the resorption of the embryozooid, but the writer has noted repeatedly that, soon after the first blastozooid opens its siphons, the ampullæ begin to grow larger again and to extend out to the periphery of the test substance from which they had been retracted. Before the first blastozooid has begun to degenerate they are considerably larger and much more numerous than they ever were during the life

of the embryozooid. Furthermore, as the colony grows, the size of the ampullæ increases, until in the large adult colonies they are very much larger than in the embryozooids. (Compare text-figures 1 and 2, both magnified 43 diameters.)

Pizon (1900, pp. 48, 49) is undecided whether to seek the decrease in the ampullæ and the shortening of their pedicels in the mechanical retraction of the ampullæ due to the decrease in the size of the zooid to which they are attached, or in an actual degeneration of the proximal part of the pedicel, similar to the resorptive processes going on in the degenerating zooid. He is, however, certain that this reduction in size is not momentaneous, such as would be produced by a contraction of the cells of the ampullar wall—a conclusion entirely in accord with that of the writer. Concerning the real cause of this decrease, however, it will be seen from the text (p. 141) that the writer considers it to be a resorption of some of the nutritive substances or living protoplasm of the cells of the ampullæ and their pedicels; and not to either mechanical retraction of the ampullæ or to a bodily disintegration and degeneration of any of its constituent cells.

The evidence which has led to this conclusion, and which is not mentioned in the text, is as follows: The tips of the ampullæ, unlike the rest of these organs, are normally composed of a rather high cylindrical epithelium. At the time when the ampullæ are retracted from the edge of the test and decrease in size, this columnar epithelium becomes much lower, and in many cases, where the colonies were kept in aquaria, was seen to disappear altogether, the tips of the ampullæ being composed of a flat epithelium, similar to that making up the rest of the wall of the ampullæ and vessels. Here, then, in the case of these columnar cells we can see some process of resorption taking place, and the conclusion seems justified, that the decrease in the size of the whole ampullæ and its pedicel is due to a similar but less evident resorptive process taking place in all of the cells of the organ.

## VII. SUMMARY.

1. The mortality of young colonies is very great. Those that survive appear to be selected on account of their greater vigor of growth.

2. The only enemies proper of *Botryllus* discovered are crabs. These were seen to eat *Botryllus* and refuse *Botrylloides*.

3. In its struggle for a substratum with other competing organisms, the only resource of *Botryllus* is rapidity of growth. The edges of the colony grow most rapidly and the center dies first.

4. Colonies of *Botryllus* did not æstivate nor hibernate. Some were kept under observation for nearly seven months. Their maximum length of life seems to be less than a year.

5. The ground-color of each zooid changes during its life. The color patterns, when present, are quite indistinct when the zooid first becomes adult; but, as it grows older, the patterns become more distinct and complex.

6. The growing edge of the colony may sometimes have a different color from the center.

7. The size and color of the zooids vary very much in the same colony at different times.

8. Colonies of *Botryllus* reared from larvæ extruded by the same colony present differences comparable in all respects to those between described species. Therefore all European and eastern North American described species should be lumped into one.

9. Certain of the color markings exhibit discontinuous variation, while others do not.

10. Unrelated colonies of *Botryllus* will not fuse with each other and cannot be grafted.

11. Unrelated colonies of *Botrylloides* do fuse when they grow toward each other and meet. There is less variation in this genus than in *Botryllus*.

12. Pieces of the same colony in both genera fuse very easily.

13. Sister and brother colonies of *Botryllus* sometimes fuse and sometimes do not.

14. It is concluded from these data that it is a certain similarity between adjacent colonies that determines that they shall not remain separate and compete with one another but shall fuse.

15. In fusing, the ampullæ of one or both adjacent colonies penetrate the test of the other and fuse with its vessels. Two ampullæ never fuse.

16. Zooids from two fused colonies may unite to form the same system.

17. The zooids in both parts of a fused colony become perfectly coördinated so far as growth and reproduction are concerned.

18. On the whole, the colony of *Botryllus* and *Botrylloides* must be considered as a single and not as a composite individual. It cannot be considered as merely the sum of its constituent zooids.

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June 11, 1901.

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## EXPLANATION OF PLATE XVII.

All the figures are drawn from living colonies growing on glass slides. The back-ground upon which the vessel containing the slide was placed was in all cases the same as the back-ground of the figures. The magnification is in all cases 10.

The drawings are everywhere as accurate as they could be made. The adjacent zooids always occupied the position represented in a single system, and were never selected from different places in the same colony. The branchial and cloacal orifices were open in the majority of cases. Within the branchial siphon the endostyle can usually be seen, and occasionally the branchial sac and tentacles were visible. The smaller bodies at the sides of the zooids are always buds where not specially referred to. Each figure represents the average color of the colony unless especially excepted.

*Figs. 1–15 represent members of Family I, derived from the larvæ extruded by a single mother colony; each represents a different colony except as specified below.*

Figs. 5, 6, 7. Two zooids from the same colony drawn on August 16, 17 and 18 respectively. The protuberances on the sides of the zooids in fig. 5 are not buds.

Fig. 8. The salmon colored spots are the ova showing through.

Figs. 11–12. Representative zooids of the same colony, drawn on June 27 and July 14.

*Figs. 16–23 represent members of Family II.*

*Figs. 17–21 represent zooids from different parts of the same colony, drawn at various times.*

Fig. 16. The mother colony of Family II, a few weeks before death.

Fig. 17. Average appearance of zooids on June 15.

Fig. 18. Color of about one-third of the zooids, July 25.

Fig. 19. Color of about two-thirds of the zooids, July 27.

Fig. 20. Zooids from the growing edge. Most of the zooids had complete double bands, August 4.

Fig. 21. Zooids from the growing edge. Most of the zooids have more white pigment, forming more complete double bands; but they also have the other markings represented in the figure.

Fig. 23. A single system containing zooids derived from two different colonies. None of the zooids of the colonies here represented are figured elsewhere.

Fig. 24. Mother colony of colony represented in next figure.

Fig. 25. Offspring of colony in fig. 24.

Fig. 26. An *average* zooid from the *middle* of a collected colony.

Fig. 27. An *average* zooid from the *growing edge* of the same colony.

### ABBREVIATIONS USED.

*A.*—Ampullæ.

*O.*—Old zooid undergoing degeneration.

*Y.*—Young zooid.

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# The Net-Winged Midges (Blepharoceridæ) of North America

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WITH FIVE PLATES

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Blepharocerid species (the new species described in this paper not included), representing ten genera, known in the world. Of these, five species, representing four genera, are found only in North America, north of Mexico; six species, of four genera, are found only in Europe; three species, of three genera, are South and Central American; and a single species is recorded from Ceylon. But one species extends its range outside of a single continent, although two genera are represented by both European and North American species. A discussion of the relationships of these widely scattered forms is included as part of this paper.

The immature stages of three of these fifteen known Blepharocerid species have been described, viz.: *Liponeura brevirostris* (Europe) by Dewitz (1880) and Wierzeijski (1881), *Curipara torrentium* (Brazil) by Fritz Müller (1881), and *Blepharocera capitata* by Comstock (1895) and the writer (Kellogg, 1900).

In this present paper the writer presents the descriptions of four new North American species found by him in the mountains of California, and, in addition, an account of the immature stages of each of these new species. The descriptions of the larval stages of at least two more species whose adult stages are not yet known are also presented; and the descriptions of larva and pupa of a species previously known only in the adult stage. In a discussion of the relationships of the North American species a table or key for the determination of these species is given, and also an account of an interesting series of modifications of the venation. The new species throw much light on what has been a puzzling venational condition in the hitherto known forms. There is also presented an account of some of the interesting structural characters of the larvæ and imagines, especially those of the larval suckers, the remarkable and suggestive condition of the compound eyes of the adult, the imaginal mouth-parts, etc. There is given also an account of the habits and life-history of the flies as far as known, with an account of the local and continental distribution of the North American species. Finally, a

statement has been added of the more serious deficiencies in our knowledge of the Blepharoceridæ, and some suggestions for the help of those who may be sufficiently interested to undertake the work of filling up some of these gaps.

## II. DESCRIPTIONS OF NEW SPECIES.

Of the four new species from California here described, two are plainly to be ascribed to the genus *Blepharocera*, of which the European species *B. fasciata* is the type species, while the other two cannot be assigned to any one of the other Blepharocerid genera as at present defined, although both ought to be included in a single genus. With a slight modification of the genus *Bibiocephala*, erected in 1875 by Osten-Sacken for the single Colorado species, *B. grandis*, the two new species can be fairly included with *B. grandis* in a single genus. And this seems preferable to establishing a new genus for them. As a matter of fact, Osten-Sacken, having but a single species in his genus *Bibiocephala*, goes so far in defining the genus that he included in his generic diagnosis what are, in the light of the new forms, better looked on as specific characters. In addition to Osten-Sacken's species and the two here mentioned, the genus *Bibiocephala* as thus widened would also include von Röder's genus *Agathon*, established in 1890 for the single Nevada species *A. elegantulus*, found also by Aldrich in Idaho and by the writer in Colorado. This relationship of species is discussed in some detail in a succeeding portion of this paper.

### 1. **Blepharocera jordani**, sp. nov.

PLATE XVIII, FIG. 1; PLATE XIX, FIG. 3; PLATE XX, FIGS. 1 AND 2.

Eyes (Pl. XVIII, fig. 1)) of both male and female bisected and nearly contiguous; the upper part of each eye is composed of larger ommatidia (apparent externally in the larger corneal facets) than the lower part; in the female the upper part of the eyes is larger in proportion to the lower part than in the male, and is prominent and bulging; in both sexes the upper

part of the eyes is red-brown, while the lower part is blackish; antennæ about twice as long as head, composed of fourteen segments; forelegs of female much shorter than middle and hind legs; not so in male; in both sexes middle legs nearly as long as hind legs; hind tibiæ with a pair of small spurs, fore and middle tibiæ without spurs; wings (Pl. XIX, fig. 3) with venation as in *Blepharocera fasciata* (Europe) and *capitata* (northeastern North America), that is, with $M_1$ incomplete (incomplete vein in the hind margin), no cross-vein between media and cubitus (no cross-vein between veins four and five), and $R_1$ wholly fused with $R_2$ (second vein simple, without branch); body not hairy, and pale fuscous in color without special markings.

Length, male 10 mm.; female 11–12 mm.

One free-flying adult male, San Francisquita Creek, near Stanford University, May 19, 1901; and numerous males and females dissected out from pupal cases, the specimens being fully developed and ready to issue; taken in April, May, and June, 1900 and 1901, from Corte de Madera, San Francisquita, Los Trancos, Steven's, Campbell's and Los Gatos creeks, all in the Sierra Morena and Santa Cruz mountains, within twenty miles of Stanford University, California; and in Smith's Creek (Mount Hamilton) and Coyote Creek (near Gilroy Hot Springs) in the Coast Range, at thirty-five and sixty miles respectively from Stanford University, California.

This distribution is practically the same as that so far determined for the species *Bibiocephala comstocki* and *Bibiocephala doanei*. Named for Dr. David Starr Jordan.

*Immature Stages.* The larvæ (Pl. XX, figs. 1 and 2) are, when full grown, 7 mm. to 9 mm. long; the lateral processes are short and inconspicuous; there are no strong markings, the whole body being mostly pale and comparatively soft (*i. e.*, not strongly chitinized); the dorsal surface of each segment bears traces of an incomplete quadrangular, blackish patch; the markings of the head consist of a median patch bearing a central triangle and two diagonal lines on each side of it, and a pair of lateral patches.

The pupa measures from 5.5 mm. to 6.5 mm. in length, is black, and is characterized by having its dorsal prothoracic respiratory plates markedly curving inward, so that the tips nearly or quite meet, the inner margin of the plates being thus strongly concave. The plates themselves are rather broad (as contrasted with the similarly inward curving but narrow plates of *Bibiocephala doanei*).

Both larvæ and pupæ of *B. jordani* are found commonly associated with the larvæ and pupæ of *Bibiocephala comstocki* and *B. doanei*.

## 2. Blepharocera osten-sackeni, sp. nov.

PLATE XVIII, FIG. 2; PLATE XIX, FIG. 2; PLATE XX, FIGS. 3 AND 4.

Eyes of female contiguous, and bisected by an unfacetted stripe; eyes of male separated by a considerable space, and bisected by a line, the upper or large-facetted portion including a much larger part of the eye in the females than in the males, this part in the male (Pl. XVIII, fig. 2) being unusually small (as compared with other species); antennæ a little more than twice as long as head, 14-segmented; forelegs not much shorter than middle legs either in female or male, hind tibiæ with spurs, others without, ungues strong and with a few longish spiny hairs at base; wings (Pl. XIX, fig. 2) with typical venation of *Blepharocera*, that is, with $M_4$ incomplete (incomplete vein in the hind margin), no cross-vein between media and cubitus (no cross-vein between veins four and five), and $R_2$ wholly fused with $R_3$ (second vein simple without branch); body without special markings, pale fuscous.

Length, male 4-5 mm.; female 5-6 mm.; the smallest member of the family so far known.

Described from several males and females dissected from pupal cases (these specimens certainly showing all the characteristic imaginal characters except, perhaps, the coloration; also they may not show quite the full length, *i. e.*, size, of free-flying specimens.

Collected near Mount St. Helena, Napa County, California; larvæ and pupæ taken also from a tributary of the North Fork of the Salmon River, near Sawyer's Bar, Humboldt County, California, and from near Castella, Shasta County, California; all of these localities being in the northern third of the State. There are also a few specimens of this species taken from the stomachs of trout from Battle Creek, California. Named for Baron von Osten-Sacken.

*Immature Stages.* The larvæ (Pl. XX, figs. 3 and 4) when full grown are 5–6 mm. long; dorsal surface of body dark, with transverse sutures between the segments broadly whitish, and a whitish spot near the lateral margin of each segment, giving the effect of an interrupted, broad, whitish, longitudinal line along each side of the body; these markings are in some specimens accented so that a strong black and white pattern is formed; in others the whitish is nearly lacking, so that the whole dorsal aspect is nearly uniform blackish; ventral aspect white with the suckers black; lateral processes short; single, and dark-colored.

The pupæ are about 4 mm. long, thus being conspicuously smaller than the known pupæ of any other Blepharocerid. The prothoracic dorsal respiratory plates are rather broad and incurved.

### 3. Bibiocephala comstocki, sp. nov.

PLATE XVIII, FIGS. 6 AND 7; PLATE XIX, FIG. 6; PLATE XX, FIGS. 5 AND 6; PLATE XXI, FIG. 4.

Eyes (Pl. XVIII, figs. 6 and 7) of both male and female separated by a narrow space, and bisected by a narrow unfacetted stripe; upper, large-facetted portion of each eye larger in proportion to rest of eye in female than in male, antennæ twice as long as head or a little more, 14-segmented, the two basal segments annulated with white; hind legs longer than the subequal middle and fore legs, the hind tibiæ with spurs, other tibiæ without spurs, the ungues strong and with the basal half bearing numerous short, fine hairs; wings (Pl. XIX, fig. 6) with a cross-vein between media and cubitus (cross-vein connecting veins four and five) and with $R_2$ distinct for a short distance but running into $R_1$ about one-third of the distance from the origin of $R_2$ to the tip $R_1$ (second vein with a short anterior branch which begins proximad of the origin of the third vein, and which runs into the first vein about one-third of the distance from the origin of the second vein to the tip of the first vein); a faintly indicated subcostal vein (auxiliary) is apparent, which extends about half the length of the costal margin; body covered with fine blackish pile.

Length, male 7.5–8.5 mm.; female 9–10 mm.

Described from one free-flying male, Campbell Creek, near Congress Springs, Santa Clara County, California, April 6, 1900, and from numerous males and females dissected out of pupal cases taken from Los Gatos, Corte de Madera, Stevens, Alembique, Los Trancos, and Campbell creeks, and from Bear Gulch, from March to May, 1900 and 1901—all these streams being in the Santa Morena and Santa Cruz mountains, within twenty miles of Stanford University, California. Named for Professor J. H. Comstock.

*Immature Stages.* The larvæ (Pl. XX, figs. 5 and 6) when full grown measure from 9 to 12 mm. in length; dorsal surface of the body pale ground-color, with a broad, transverse darkish bar, usually indistinctly outlined on each body segment; near the middle of each segment a pair of small black spots always present, though sometimes rather faint; lateral processes double, not very long, the anterior one of each pair being the longer and slenderer, and blackish all over, the posterior one being dark brown below and whitish above; the ventral suckers unusually small, the antennæ unusually long; the tufts of tracheal gills consisting of four tubules each.

The pupæ (Pl. XXI, fig. 4) are from 7 to 8 mm. long, black (not dark brown) and with short, broad, prothoracic respiratory plates, the two groups of plates being set more closely together than usual with Blepharocerid pupæ.

## 4. [1] Bibiocephala elegantulus *von Röder.*

PLATE XVIII, FIGS. 4 AND 5; PLATE XIX, FIG. 5; PLATE XX, FIGS. 9 AND 10; PLATE XXI, FIG. 7; PLATE XXII, FIGS. 7 AND 8.

Eyes (Pl. XVIII, fig. 5) of male separated rather widely, and bisected by a narrow line, the upper, large-facetted portion of the eye being one-fourth of the whole eye; in female (Pl. XVIII, fig. 4) the eyes are separated by a narrow space, and bisected by a line, the upper, large-facetted portion forming about one-third of the whole eye; antennæ 14-segmented, and about one and one-half times as long as head; hind legs longer than subequal middle and fore-legs, hind tibiæ with spurs, middle tibiæ with very small spurs, fore tibiæ without spurs, ungues rather strongly curved, not incrassate; wings (Pl. XIX, fig. 5) with a cross-vein between media and cubitus (connecting veins four and five) with $R_2$ present as a very short vein running so quickly into $R_1$ as to form a nearly equilateral triangle (a short anterior branch of the second vein running into the first vein close to the origin of the second vein); $R_3$ and $R_4$ usually arise from a common point but are not stemmed, a short stem, however, sometimes being present, and in this case there may be a cross-vein connecting the two near the point of forking (veins two and three usually sessile but occasionally having a very short stalk); a short subcostal vein (auxiliary) is usually indicated; dorsal and lateral aspects of thorax dark brown, ventral aspect whitish; dorsal aspect of abdomen dark brown, with narrow, transverse sutural lines, ventral aspect whitish; legs pale brown; antennæ and head except the red-brown, upper, large-facetted portion of eyes blackish.

Length of male 8.5 mm.; female 10 mm.; body of female (Pl. XXI, fig. 7) much more robust than in male.

Described from numerous free-flying males and females taken in July and August, 1900, from Big Thompson River, at the mouth of Willow Park, altitude 7,500 feet, in Estes Park, Larimer County, Colorado; same species found also in Wind River, Mill River, and South Fork, streams tributary to the Big Thompson. Originally described by von Röder as a new genus, *Agathon*, from Nevada. Aldrich has found it in Idaho.

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[1] In the paper as sent to the printer, the writer had described this as a new species, being led to do this by von Röder's contradictory account of the venation of *Agathon*. Von Röder's account deceived also Osten-Sacken and Williston, who thus wrongly enter *Agathon* in their synoptic tables. Professor Aldrich, however, called the writer's attention to the fact that although von Röder uses the word "*fere*" instead of "*ante*" in his Latin description of the species, in his German description of the genus the contrary (and true) condition is properly described. Von Röder also unfortunately gives an ambiguous locality for his species in the words "Patria: (Sierra) Nevada, America sepentr. (Morrison)." In a letter to Professor Aldrich, Baron von Osten-Sacken states that Morrison found the specimens in the State of Nevada and not in the Sierra Nevada (mountains of California).

*Immature Stages.* Larvæ (Pl. XX, figs. 9 and 10) red-brown above, with four small but distinct black spots on dorsum of each body segment; lateral processes rather pronounced, double, the anterior one of each pair angulated, both processes dark brown; tracheal gill-tufts composed each of four tubules, two projecting anteriorly and two posteriorly; antennæ rather short, length 6–8 mm.

Pupæ black, with short, broad, slightly curving, dorsal, prothoracic respiratory leaves; length 7 to 8 mm.

## 5. Bibiocephala doanei *Kellogg.*

PLATE XVIII, FIG. 3; PLATE XIX, FIG. 4; PLATE XX, FIGS. 7 AND 8; PLATE XXI, FIG. 3; PLATE XXII, FIGS. 9, 10 AND 11.

*Liponeura doanei* KELLOGG, Psyche, Vol. IX, 1900, p. 39.

This species, the first of the new Californian species found, was first described as a *Liponeura*, but in the light of the other forms the species should be removed to the genus *Bibiocephala*. For the purpose of making this paper complete, the essential parts of the description as already published are repeated here, and the description of the male and of the immature stages are added. At the time of describing the species, only the adult females were at hand in condition for description.

*Female.*—Length 6 mm.; length of wing 7.5 mm.; very pale brown, almost clayey; antennæ 14-segmented and rising from a prominence which might be construed as a basal antennal segment; eyes broadly separated, and with no indication of bisection, the facets being all of the same size; eyes in the male (Pl. XVIII, fig. 3) broadly separated, and bisected by a distinct line; the mouth-parts (Pl. XXII, figs. 9, 10 and 11) long (distinctly longer than in *Blepharocera*, for example); wings with venation (Pl. XIX, fig. 4) showing the following characters, vein $M_3$ independent, *i. e.*, without connection with $M$ or any other principal vein (an incomplete vein running into the posterior margin between veins four and five); vein $R_2$ present as a very short spur running so quickly into $R_1$ as to form a small triangle with $R_2$ as the shortest leg (a short anterior branch of the second vein running into the first vein close to the origin of the second vein); a medio-cubital cross-vein (a cross-vein between veins four and five); veins $R_2$ and $_3$ and $R_4$ and $_5$ separating at the origin of the radio-medial cross-vein (the submarginal cell sessile); the radial sector springing from $R$ by two roots (the cross-vein between veins one and two Y-shaped, *i. e.*, the anterior half of it divided, enclosing a small triangular cell); subcosta wanting or with only a basal rudiment present (auxiliary vein wanting or with only a basal rudiment present); wings clear, with strong iridescent reflections); legs long, the three pairs of about equal length,

the hind tibiæ bearing a single terminal spur, the other tibiæ without spurs; tarsal claws large, thick, and strong with curved, pointed tip, thickly pectinate except at the tip.

Described from two females and one male, taken by R. W. Doane, July 24, 1895, on the banks of a small stream in the Santa Cruz Mountains, at Congress Springs, Santa Clara County, California. In addition, the writer has dissected practically adult males and females from pupal cases found during February, March, and April, 1900 and 1901, in Los Gatos, Campbell, Stevens, Los Trancos and Corta Madera creeks—all in the Santa Cruz and Santa Morena mountains, within twenty miles of Stanford University, California. The writer has also taken specimens in Coyote Creek, near Gilroy Hot Springs (April), in the Coast Range; and G. A. Coleman collected larvæ and pupæ in Red Cap Creek, Hoopa Indian Reservation, Humboldt County, California, July 26, 1901. Named for Mr. R. W. Doane.

*Immature Stages.* Larvæ (Pl. XX, figs. 7 and 8) rather broad and short, with strongly chitinized dorsal body-wall; each segment, except the head and thoracic segment with one, with two rough, black, transverse bars; lateral processes rather conspicuous, double, the anterior member of each pair the longer, and with hairs at its tip; tracheal tufts composed of six tubules, two of which project laterally, the others anteriorly; length 7 mm.

Pupa (Pl. XXI, fig. 3) black, with narrow, high, incurving respiratory plates, the two members of the pair being set widely apart; length 6 mm.

## *Larvæ of Two Additional Species.*

In addition to the five Blepharocerid species just described, the writer has found the larvæ of two additional species whose pupæ and adults have not yet been found. As both of these larvæ, one found in Colorado and one in California, present external features of particular interest, they are here figured and the following brief descriptions of them are given, without, of course, offering names for the species; it may be, indeed, and is to be hoped, that the Colorado one is the larvæ of Osten-Sacken's *Bibiocephala grandis* (described by him from Colorado), and the

California one the larva of his *Blepharocera ancilla* or *Liponeura yosemite* (both described from California).

*New Colorado Larva* (Pl. XX, figs. 11 and 12). Short and broad; dorsal aspect blackish, rugose, strongly chitinized; lateral processes long and prominent, double, and both members of each pair provided with numerous hairs; the anterior member of each pair longer, angulated, and bearing at its tip a very long, spiny hair; these lateral processes pale fuscous in color; the tracheal tufts composed of six large tubules, three of which project anteriorly and three posteriorly; the ventral suckers unusually large, and larger than in any other Blepharocerid larva yet seen by the writer; the dorsum of the head and thoracic body segment elaborately marked with blackish, brownish and pale fuscous; on under side of this segment a lateral, longitudinal row of three conspicuous pale dots, each with fine black pin-point center; length 7 mm.

These larvæ were found in same places as those of *Bibiocephala elegantulus*, and were quite as common.

*New California Larva* (Pl. XXII, figs. 1 and 2). Short and broad; brownish above, elsewhere pale yellowish white, the dorsal aspect of posterior body segment also pale yellowish white with blackish posterior margin; lateral processes double, long, and fringed with numerous hairs; the anterior process of each pair longer, not angulated, and darker above than posterior one; these processes longer than in any other Blepharocerid larva known to the writer; antennæ unusually long; tracheal tufts composed of four tubules, all projecting anteriorly; length 5.5-6 mm.

These larvæ were found scatteringly and rarely in most of the streams, viz., Los Gatos, Campbell, and Alembique creeks, etc., near Stanford University, in which were found *Bibiocephala comstocki* and *B. doanei*.

## III. Discussion of the Classification of the North American Species.

The whole family Blepharoceridæ is readily divisible into two groups, of which one, characterized by the absence in its members of a short incomplete vein near the posterior margin of the wing, includes six genera, each represented by a single species, none of which is found in North America north of Mexico. These six genera and their distribution are *Apistomyia* (Corsica, Cyprus), *Hapalothrix* (Monte Rosa, Switzerland), *Hammatorhina* (Ceylon), *Curipara* (Province St. Catharina, Brazil), *Snowia* (Rio

Janeiro, Brazil), and *Paltostoma* (Columbia, South America, Mexico and West Indies).

The remaining known species are grouped, in the latest revision (Osten-Sacken, 1895) of the family, into four genera, of which two, *Bibiocephala* and *Agathon*, each with a single species, are recorded only from the western United States, while the other two, *Blepharocera* and *Liponeura*, with respectively three and four species each, have representatives in both Europe and the United States. The species recorded from North America, according to this revision, are *Blepharocera capitata* (Northeastern United States and reaching far north), *Blepharocera ancilla* (California), *Liponeura yosemite* (California), *Bibiocephala grandis* (Rocky Mountains, Colorado), and *Agathon elegantulus* (Nevada). Of these species male specimens alone are known of *Bibiocephala*, *Agathon* and *Liponeura;* females alone of *Blepharocera ancilla*, and both sexes of *Blepharocera capitata*. In the light thrown upon the value of the characters used by Loew, Osten-Sacken, and von Röder in their establishment of genera, by the four new species described in this paper, of which males and females are known in every species, it becomes necessary to suggest a re-revision of the Blepharocerid genera. This suggestion is made with distinct reluctance, but the simple observation of the existing facts dictates it.

The contiguity or separation of the eyes, and their bisection, have been relied on as generic characters; but it is obvious from the conditions shown by the new species *Bibiocephala doanei*, in which the eyes of the male are bisected while those of the female are not, and from the condition of *Bibiocephala (Agathon) elegantulus*, where the males have the eyes separated by a broad space while the eyes of the female are subcontiguous, that such distinctions cannot distinguish genera, if, indeed, even specific value may be given them. On the other hand, an inspection of the venation of the wings shows that forms with identical venation or with variations amounting (as will be shown) simply to slight differences in degree, not in kind, have

been assigned to independent generic rank, while apparently important venational differences have not been allowed to interfere with the assignment of several species to a common genus.

By a careful inspection of the venational condition shown by all the so far known North American species (in the case of *Blepharocera ancilla* and *Liponeura yosemite* only the descriptions and figures of the wings were had for reference), it has seemed to be not difficult to suggest a classification based on these conditions, which is not open at least to the grave defects of a classification based on characters which are seen (in the newly-found forms) to vary with the sexes in a single species. As this revision tends to reduce the number of genera rather than increase it, its author cannot be charged with anxiety to revise for the sake of making new names! As a matter of fact, it is but following the excellent suggestion of Osten-Sacken, made in his revision (l. c., p. 160) in words as follows: "To those who will continue the work on Liponeuridæ [=Blepharoceridæ] I would humbly recommend, as a result of many years of experience, not to multiply the genera unnecessarily. * * * When in such decadent groups we multiply the genera too much they in the end become all monotypical, and thus baffle the pursuit of classification, as the survey of their mutual affinities becomes more difficult. The true end of classification is an easier survey of affinities, a temporary aid to the memory."

The changes suggested here are, briefly, that Osten-Sacken's genus *Bibiocephala*, erected for the single Colorado species *B. grandis*, be widened (by cutting out some of the specific characters of *B. grandis* included in the definition of the genus) so as to admit the new species *comstocki* (California) and *doanei* (California), described in this paper, and von Röder's species *elegantulus* (Colorado); that the genus *Blepharocera* be limited to and include all forms which have no distinct radius$_2$ (anterior branch of second vein) and which have no media-cubital cross-vein (cross-vein connecting veins four and five); and that

*Liponeura* include those forms without a distinct radius$_2$ (anterior branch of second vein) but with a media-cubital cross-vein (cross-vein connecting veins four and five). The type species of *Blepharocera* will continue to be *Blepharocera fasciata*, the common European Blepharocerid described by Westwood in 1842; and to this genus will belong the three American species, *B. capitata* Loew, *B. jordani* Kellogg, and *B. osten-sackeni* Kellogg, and the two European species now called *Liponcura cinerascens* Loew and *L. brevirostris* Loew. As *L. cinerascens* is the type species of the genus *Liponeura*, a new generic name will have to be given to those other species, *bilobata* Loew and *yosemite* O.-S., which were included with *L. cinerascens* in the genus *Liponeura*, but which cannot be transferred with *L. cinerascens* to the genus *Blepharocera*. The name *Philorus* (mountain-loving) is here suggested for these forms. Included with *bilobata* and *yosemite* in this genus *Philorus* would come Osten-Sacken's *Blepharocera ancilla*. By this arrangement von Röder's *Agathon elegantulus* should be included in *Bibiocephala*.

The following analytical tables will show the relation of the genera under the present suggested revision:—

ANALYTICAL TABLE OF GENERA OF NORTH AMERICAN BLEPHAROCERIDÆ.

I. An incomplete media$_3$ lacking (=no incomplete vein near the posterior margin of the wings).

*Apistomyia* (Corsica, Cyprus), *Hammatorhina* (Ceylon), *Paltostoma* (Columbia, Mexico, West Indies), *Snowia* (Rio Janeiro), *Curupira* (Brazil), *Hapolothrix* (Monte Rosa, Europe).

II. Media$_3$ present but incomplete (=an incomplete vein near the posterior margin of the wings).

(North American and European species.)

*A.* Radius$_2$ partly distinct (=second longitudinal vein with two branches); a cross-vein between media and cubitus (=cross-vein connecting veins four and five).

Radius$_2$, radius$_3$ and radius$_4$ all separating at a common point or close together (=anterior branch of second vein, and veins two and three all separating at a common point or close together).

*Bibiocephala* (Pl. XIX, figs. 4, 5, 6 and 7).

*A. A.* Radius$_2$ wholly fused with radius$_3$ (=second longitudinal vein simple, without branches).

*B.* No cross-vein between media and cubitus (=no cross-vein connecting veins four and five).

*Blepharocera* (Pl. XIX, figs. 1, 2 and 3).

*B. B.* A cross-vein between media and cubitus (=a cross-vein connecting veins four and five).

*Philorus* (Pl. XIX, figs. 8 and 9).

TABLE OF SPECIES OF BIBIOCEPHALA.

Eyes contiguous; $r_2$ running into $r_1$ near the margin of the wing (=anterior branch of second vein running into vein near margin of the wing); eyes bisected; fore femora of male strongly curved.

1. *B. grandis* O.-S. (Colorado, Utah, Idaho).

Eyes separated by a narrow or broad space, in both males and females; eyes bisected; fore femora of male straight.

Eyes of both male and female bisected.

Eyes of male separated widely; of female narrowly; $r_2$ running into $r_1$ (anterior branch of second vein running into first vein) very soon, forming a nearly equilateral triangle.

2. *B. elegantulus* von Röder (Nevada, Idaho, Colorado).

Eyes of both male and female separated narrowly; $r_2$ running into $r_1$ at about one-third of the length of the distance from origin of radial sector to the tip of $r_1$ (anterior branch of second vein running into first vein at about one-third the distance from origin of second vein to tip of first vein).

3. *B. comstocki*, sp. nov. (California).

Eyes of male bisected; of female not bisected; $r_2$ running into $r_1$ very soon, making a triangle in which $r_2$ forms the shortest side (anterior branch of second vein running into first vein very soon making a triangle in which anterior branch of second vein forms the shortest side).

4. *B. doanei* KELLOGG (California).

TABLE OF NORTH AMERICAN SPECIES OF BLEPHAROCERA.

Eyes of female contiguous, of male separated by broad space; length not over 6 mm.

1. *B. osten-sackeni*, sp. nov. (Northern California).

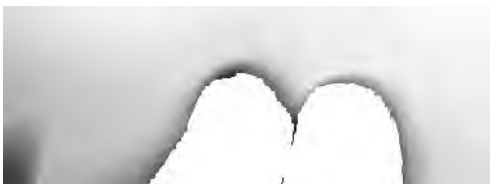
Eyes of both sexes separated by narrow space; length not less than 7 mm.

Ungues slender and rather long.

2. *B. capitata* LOEW (Northeastern United States).

Ungues stout and shorter.

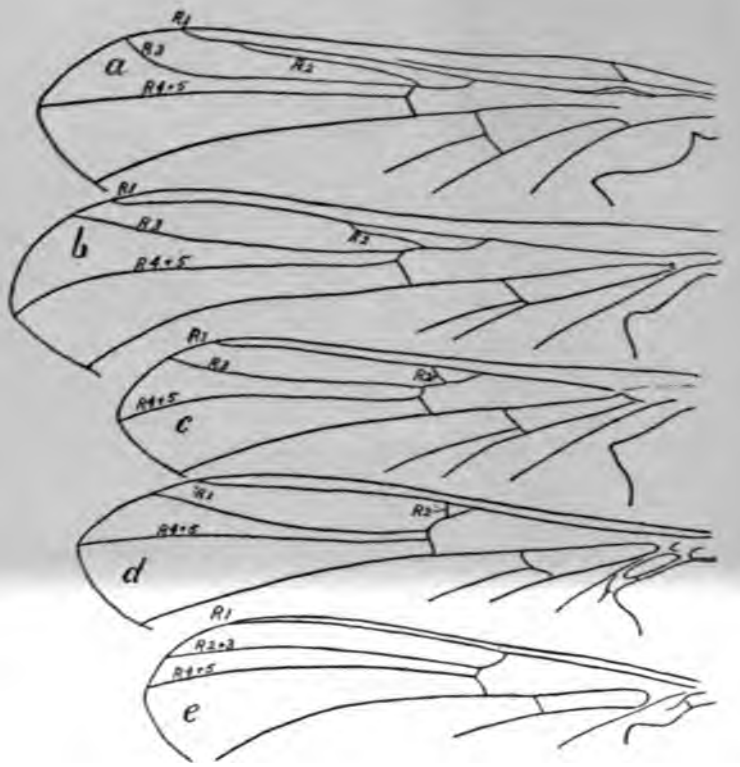
3. *B. jordani*, sp. nov. (California).



It seems unnecessary in the face of the descriptions and figures of the new species here recorded, and of the contrasting characters as indicated in the foregoing analytical tables, to argue for the soundness of this suggested revision, based on venation; or rather for the unsoundness of the old classification based on continuity and bisection of the eyes. It may indeed be necessary to revise again the generic classification when another half dozen species are found, but this further revision cannot possibly be based on eye characters; it will probably be based on venational characters. It is not a long step from a slightly free $radius_2$ (=anterior branch of second vein) as shown by *Bibiocephala doanei* and *B. elegantulus* to one wholly fused with $radius_1$ or $radius_3$ (with the first or second vein), as is the case in *Blepharocera* and *Philorus*. Indeed so obviously is this difference simply a matter of degree of serial modification or specialization that it is a question whether the species of *Philorus* and *Bibiocephala* should not be looked on as members of a single genus, distinguished from *Blepharocera* by the possession of a medio-cubital cross-vein (cross-vein connecting veins four and five).

The series formed by *Bibiocephala grandis*, *B. comstocki*, *B. elegantulus*, *B. doanei*, and *Philorus bilobata*, with regard to the addition of the radial vein as shown in text-fig. 1, is very suggestive. It is certainly a pretty demonstration of what that formerly mysterious little triangle, which was found and puzzled over in *Bibiocephala doanei* (see the original description of *doanei* as a *Liponeura* in Psyche, Vol. IX, pp. 39–41) really is.

This serial modification (by increasing fusion of one radial branch with another) has been elsewhere prettily shown by Comstock (Manual, pp. 442–443) after Winnertz, in the case of certain Mycetophilid species, in which a series almost exactly similar to the one just shown above is described, except that the fusing vein is not $radius_2$ but is a vein formed by the already complete fusion of $radius_2$ and $radius_3$.




TEXT-FIG. 1.

**Fig. 1. Diagram showing the condition of the radial branches in (*a*) *Bibiocephala grandis*, (*b*) *Bibiocephala comstocki*, (*c*) *Bibiocephala elegantulus*, (*d*) *Bibiocephala doanei*, and (*e*) *Philorus bilobata*. These five species form a series in which radius$_2$ proceeds from a condition in which it is free for almost its whole length to a condition of complete coalescence, *i. e.* disappearance.**

## IV. NOTES ON THE STRUCTURE OF LARVÆ AND IMAGINES.

The published notes on the structure of the Blepharoceridæ, in addition to the external details more or less superficially described in the specific descriptions of various authors, are included in the papers of Dewitz (1880), Müller (1881), and the writer (1898, 1899, 1900).

The suckers of the larvæ are described in more or less detail by all of these writers (in each case for a different species). For the sake of making this paper as nearly as may be, in brief compass, an introduction to the study of the North American Blepharoceridæ, there is here quoted part of the already published description, with the figures, of the suckers of the larvæ of *Blepharocera capitata* (Kellogg, 1900).

The body of the larva consists of six parts, separated by distinct constrictions. By making sagittal longitudinal sections through the body it can be seen that the anterior, apparently single, segment is composed of the fused head and three thoracic segments, while the most posterior part is composed of the last two abdominal segments, the intervening parts representing each a single abdominal segment. That the anterior body part comprises the head and thoracic segments is also proved by the fact that the imaginal discs of the legs and wings are to be found here. The larva is footless; but each body part (not body segment) bears a pair of small, unsegmented, pointed projections (Pl. XXI, fig. 6, *l. p.*), situated on the ventral aspect of the lateral margins. This projection may be of slight use to the larva in locomotion, but, at best, only of slight use. The real organs of locomotion and of attachment to the rock bed of the stream are the six "suckers," one of which lies on the median ventral aspect of each body part. There is but one sucker for the combined head and thorax, and but one for the last two abdominal segments. By means of these suckers the larva clings to the rock bed of the stream, despite the impact of the swiftly flowing water. The larva

can loosen its hold with the suckers voluntarily; and, by loosening those at one end of the body, swinging this end laterally and refastening it, and then loosening the other end of the body and swinging and refastening it, a slow but safe locomotion, chiefly lateral, is possible. The larvæ move about not a little, especially from the necessity of continually moving from the edge out farther into the stream as the water of the little stream gradually lessens in quantity.

The structure of these suckers and the manner of their working are of interest. The ventral (external) aspect of a sucker (Pl. XXI, fig. 5) shows a central opening, surrounded by a strong, flexible, concave rim, marked with alternating concentric thicker and darker and thinner and lighter bands of chitin. The rim projects considerably ventrad, so that a considerable free or air space is enclosed by the rim when its outer edge is applied to any surface. In dorso-ventral sections transversal to the body of the larva (Pl. XXI, fig. 6), the whole structure of the sucker is apparent. The cup-shaped sucker is seen, after all, not to consist of a rim around a circular opening, but to be simply a part of the outer body-wall (true skin and chitin cuticula) peculiarly folded and modified to act as a sucker. The projecting cup-like part of the sucker is coated with chitin, so as to be thick and strong, although still flexible. At its base the skin is almost free from chitin, thrown into fine folds, and bent in toward the interior of the body and then out again. Here it is greatly thickened by a circular, lens-shaped deposit of chitin, which is slightly larger than the inner neck of the sucker, which it closes internally. The neck of the sucker is the apparent central opening, and the lens-shaped thickening is the bell-shaped structure, which closes this opening internally, as seen in looking at the sucker from the under or external side. The structure of the sucker is all plainly shown in Pl. XXI, fig. 6, and can be much more readily understood from an inspection of the figure than from reading this description. Attached to the inner face of the lens-shaped "stopper" of the sucker are two great muscles which run dorsally and

somewhat diagonally clear through the body-cavity to the dorsal walls, to which they are attached. The muscles do not rise directly from the "stopper," but are fastened to it by strong, short tendons. The manner of the sucker's functioning can now be understood. With the rim resting on a smooth surface, the rock bed of the stream, and the "stopper" well down in the neck of the air-cavity of the sucker, the lifting muscles may be contracted, the "stopper" raised (the folds at the neck give chance for a considerable movement of the "stopper"), and a partial vacuum formed with the sucker. What muscles are used when the insect desires to loosen the hold of a sucker is not so evident. Probably the contraction of certain dorso-ventral muscles which lie lateral of the muscles which lift the "stopper" serves to force the "stopper" down by flattening the body dorso-ventrally. So firmly can the larvæ hold to the rock bed by means of these suckers that one often tears a larva in two in attempting to remove it.

*Imaginal Mouth-parts* (Pl. XXII, figs. 9, 10 and 11). In the imago the structural conditions of special interest are those presented by the mouth-parts and the eyes. The following account, with the figures of the mouth-parts of *Bibiocephala doanei* Kellogg, is taken from Psyche, Vol. IX, 1900, pp. 39–41:

The mouth-parts of the female consist of the following well developed, independent, and easily distinguishable parts shown in Pl. XXII, fig. 9, *in situ* to reveal the relative size and natural position with regard to each other; a labrum-epipharynx (*l. ep*), a pair of mandibles (*md*), a pair of maxillæ (*mx*), a labium (*li*) and a hypopharynx (*hyp*).

The labrum-epipharynx is elongate, slender, and pointed, and bears numerous taste-pits (?) on its lower (inner) surface, which is concave.

The mandibles are long, slender, well chitinized, and each is sharply, finely, and conspicuously serrate along the distal half of the inner margin. The mandibles are articulated with the head-capsule, wholly distinct from the other mouth-parts.

The maxillæ consist of a single short, tapering, blade-like, thin but well chitinized maxillar lobe, and a long, slender, five-segmented palpus. Lobe and palpus arise from a basal sclerite, which shows no differentiation into cardo and stipes, and may be taken to represent these two sclerites completely fused.

The labium consists of a strong, elongate, basal sclerite which presents indications of a line of fusion of submentum and mentum, and a pair of free, fleshy, terminal lobes, the paraglossæ. These terminal lobes have no pseudo-tracheæ. There are no palpi.

The hypopharynx is as long or slightly longer than the labrum-epipharynx, is narrower, and although thin, well chitinized. It lies along the dorsal surface of the labium, underneath the labrum-epipharynx.

The mouth-parts, excepting the mandibles, are carried somewhat forward by the extension of their bases or of the frontal part of the head-capsule. The various parts of the mouth dissect apart readily.

In *Blepharocera capitata* Loew a similar condition of the mouth-parts exists, as may be seen from the following account taken from Entomological News (Kellogg, 1900):

"The females of *Blepharocera*, like the females of *Simulium*, *Ceratopogon*, *Dixa*, *Culex*, and some other Nematocera, are blood-sucking, and while the mouth-parts of these forms are not strictly biting, the mandibles are present, as cutting or sawing or piercing organs. The males of these forms are nectar-feeding, and have lost the mandibles. In the mouth-parts of the female *Blepharocera* all of the parts of the typical biting mouth are present, the mandibles, maxillæ and labium. The mandibles are long and serrate on their inner edges, so as to be effective lacerating instruments. The maxillæ are elongate and blade-like and have four-segmented palpi. The labium is, though somewhat elongated, truly tip-like, and has its terminal lobes not coalesced and without pseudo-tracheæ. The hypopharynx is not short and tongue-like, as in the orthopterous mouth, but is long and slender and stylet-like.

Altogether the difference between the mouth-parts of *Blepharocera* and the typical biting type is one of modification, and of modification not sufficient to obscure the homologies, although a modification more profound than that shown by the most generalized Lepidoptera or Hymenoptera. On the other hand, there is not much difficulty in tracing the development of the dipterous mouth from the generalized condition of *Blepharocera* (or *Simulium*, or *Dixa*, *et al.*) to that extraordinary specialized condition shown by *Musca*, where the mandibles and maxillæ are lost, and the labium is so modified that it has no longer any likeness to the 'lower lip' of the orthopterous mouth."

Although it has seemed from a comparative study of the imaginal mouth-parts of all the nematocerous (generalized) families of Diptera (excepting the Ornephilidæ) and of most of the brachycerous (specialized) families, that the homologies of the mouth-parts can be satisfactorily determined, certain entomologists have refused to recognize the determination of homologies thus based to be conclusive. With this in mind, and recognizing, indeed, the general desirability of testing by ontogenetic study any conclusions arrived at from comparative anatomical study, the writer has studied the post-embryonal development of the mouth-parts of representatives of two of the nematocerous families of Diptera, the Simulidæ and Blepharoceridæ, whose females are equipped with what are here said to be all the recognized parts of the generalized orthopterous, or typical biting mouth. These parts are indeed much modified, the mandibles in particular being oddly elongated and serrated to form a pair of rasping knives, or saws, with which the body of the prey (smaller insects, especially Chironomids) is lacerated so that the blood and body juices may be sucked.

In this study, the results of which are published elsewhere in connection with studies of the development of the imaginal mouth-parts of other orders of insects with complete metamorphosis (Kellogg, 1902), it has been possible to trace the development of the imaginal parts within the head of the

larvæ from beginning to complete condition, and to ascertain that the correspondence between the greatly modified parts of the adult mouth, adapted for lacerating and lapping or sucking, and the generalized biting parts of the larva can be satisfactorily established, mandible for mandible, maxilla for maxilla, and labium for labium. In the larval mouth the homologies of the parts with the parts in the biting orthopterous mouth are apparent. They can be traced, of course, in their embryonic development from budding appendages to completed larval mouth-parts, leaving no possible doubt of their homologies; and this has been done for *Simulium* by Metschnikoff. As the eggs of the Blepharoceridæ are as yet unknown, this embryonic tracing cannot yet be done.

*Imaginal Eyes* (Pl. XXII, fig. 1). With regard to the curious condition of the eyes of the adult Blepharocerids, the following is taken from the account in the Entomological News (Kellogg, 1900) of the eyes of *Blepharocera capitata*.

The other specially interesting point in the imaginal anatomy of *Blepharocera* is the structural condition of the compound eyes. It has long been observed that several flies (*Simulium*, *Tabanus*, *et al.*) and certain other insects (Libellulidæ, *Ascalaphus*, Ephemeridæ, *et al.*) have two sizes of facets in each compound eye; that some have the field containing these differently sized facets well delimited, the fields being in some cases actually separated from each other by a non-facetted line or by a constriction. When this constriction is so complete that the eye is truly divided, it may fairly be said that there are two pairs of compound eyes, the two eyes of each lateral pair differing in the size of the facets. This last extreme condition exists in the case of the males of certain Ephemeridæ and in both males and females of *Blepharocera capitata*. [And in almost all other Blepharocerid species. See Pl. XVIII, all figures.]

The eyes of *Blepharocera* are plainly divided; or it may be said that there are two on each side (Pl. XVIII, figs. 1 and 2). One of these eyes is dark colored, has small facets, and faces anteriorly and laterally. It is fairly

convex. The other is reddish brown, is composed of much larger facets, faces dorsally, and has a nearly flat surface. This red, large-facetted dorsal eye has the appearance of a flattened mushroom head, or thick plate, resting above the other eye. In the males, the dorsal, large-facetted eye is much smaller and less conspicuous than in the female, but both parts of the eye (or both eyes) are plainly present. This difference in the two parts of the eye is more radical, however, than can be discovered by a mere examination from without. The ommatidia, or eye elements, of each of the regions differ, as shown by sections (see Pl. XVII, fig. 1.) in many particulars. Corresponding with the difference in size of the facets (the corneal lens of the ommatidia), there is a marked difference in the diameter of the ommatidia from the two regions. The ommatidia of the dorsal, large-facetted eye are nearly twice as wide, and they are fully twice as long, as the ommatidia of the small facetted eye. Another striking and important difference is this, the larger ommatidia are very much less strongly pigmented than the smaller ommatidia. There are, also, some differences in the character of the inner optic "layers" lying between the hypodermal portion of the eye and the brain; characters too technical for discussion here. In sum, however, it is evident that there is so marked a difference in structure between the two eye regions that there must be a difference in exercise of the function. The seeing by one of the eye regions differs from the seeing by the other eye region.

In a brief discussion elsewhere of the "divided eyes of arthropods" (Kellogg, 1898) reference has been made to the observations of Chun (1896), who has described the structure of the divided eyes of certain pelagic crustaceans, and to the observations of Zimmer (1898), who has studied the divided eyes of certain male May-flies. In both of these cases the eyes show two sizes of facets, and accompanying this are both those other structural differences which are apparent in *Blepharocera*, viz., the large ommatidia and small amount of pigment of the large-facetted eyes as compared with the small ommatidia and heavy

pigmenting of the small-facetted eyes. Here are three groups of arthropods, viz., certain crustaceans, May-flies, and flies, widely separated genetically and of widely varying habits, showing a common structural modification of the eyes. We have evidently to do with independent adaptations determined by some common functional need.

The large size of the ommatidia and the small amount of pigment are characters which adapt the large-facetted eyes for seeing in poor light (in the dark) and for readily perceiving moving objects (delicate perception of shadows). The normal, small-facetted eyes see more accurately the actual shape of visible objects; they have better definition, but require much light. Chun explains that the large-facetted eyes of the pelagic crustacea enable them to perceive their prey (for the crustacea possessing these eyes are all predaceous) in the poorly lighted levels of the water. The large-facetted eyes of the male May-flies enable them, according to Zimmer's explanation, to perceive the advancing female during the twilight marriage flight peculiar to these forms. What is the special use of the large-facetted eyes in the case of *Blepharocera?*

The females are predaceous; they capture other smaller live insects, and, lacerating them with the saw-edge mandibles and blade-like maxillæ, lap their blood. The males, on the other hand, presumably, do not capture insects; they have no mandibles, and are probably nectar-feeding. The female might advantageously be possessed of a number of those large, weakly pigmented eye elements which are specially adapted to the quick perception of moving objects. But what makes this explanation less convincing is the fact that the males also possess these large-facetted ommatidia, although, to be sure, in fewer number. Perhaps both males and females are active in twilight. Search as carefully as one might, never but very few of the adult *Blepharocera* could be found along the stream, from which they were certainly issuing by thousands. Until the habits of our fly are better known, then, it is hardly profitable to speculate on the special use of its large-facetted eyes.

*Imaginal Genitalia* (Pl. XXII, figs. 2, 3, 4, 5, 6, 7 and 8). The modifications of the last segments of the abdomen with their processes are marked in the different Blepharocerid species examined, and if known for all the species so far described could without doubt be advantageously used in specific, perhaps generic diagnoses. It is in the male that the more complex development of these parts, which may be called the external genitalia, takes place, and in which most difference is apparent in a comparison of species. Of the species whose genitalia the writer has examined, viz., *Blepharocera capitata*, *B. jordani* and *B. osten-sackeni*, and *Bibiocephala elegantulus*, *B. doanei* and *B. comstocki*, *Blepharocera capitata* (Pl. XXII, figs. 2, 3, 4, 5 and 6) presents the simplest type of male genitalia, and *Bibiocephala snowi* (Pl. XXII, figs, 7 and 8) the most complicated. The figures make the structure of these parts in the two species noted so obvious that a detailed description of them is unnecessary.

The other species may be grouped roughly between these two extremes, each species showing, however, its own characteristic modifications. In the female, the modifications of the segments and development of epiphyses are less marked, as shown in Pl. XXII, figs. 4, 6 and 7. The typical condition is manifest in all the species examined. The single pair of epiphyses and both the dorsal and ventral surface of the last abdominal segment bear special sense papillæ, perhaps of simple tactile function. The structure of these papillæ with their special nerve endings is shown in Pl. XXII, fig. 5.

## V. HABITS OF LARVÆ, PUPÆ, AND IMAGINES.

*Larvæ.*—The larvæ of all the Blepharoceridæ yet known live submerged in swift-running, clear streams, which practically limits their occurrence to mountainous or at least hilly regions. They are found usually in groups of lesser or greater number in favorable spots, sometimes, as in the case of *Blepharocera capitata*, in Coy Glen, near Ithaca, New York, forming "patches" of hundreds of individuals

clinging to the smooth rock bed of the stream, with from an inch to two inches of water running swiftly over them.

In Colorado and California the larvæ of *Bibiocephala elegantulus*, *B. comstocki* and *B. doanei* and those of *Blepharocera jordani* have been found more scattered and usually more deeply submerged; this is usually caused, or at least the other condition made impossible, by the broken condition of the stream beds, which are usually composed of separate stones of various sizes rather than of smooth bed rock. The larvæ cling firmly to the rock by means of the six ventral suckers (whose structure and mode of action is explained on p. 203), and when disturbed can hold so fast that the body is more readily torn in two than dislodged as a whole. Locomotion, which, though slowly, is freely accomplished, is in a lateral direction; the moving larva loosens the hold of three suckers at a time and swings to one side the fore or hinder half of the body thus released, the suckers again attach this part of the body in its new position, and the other half of the body is loosened and swung over, and thus a slow lateral translation of the larva takes place.

The larvæ appear to feed chiefly on diatoms, although other food is doubtless taken. The older larvæ of *Blepharocera capitata* almost always bear a dorsal, felt-like covering, which is composed of a close growth of diatoms. The most abundant diatom in this growth was one of the stalked *Gomphonema*. The basis of the covering is the gelatinous mass at the base of the stalked diatoms. Scattered upon and through this mass were individuals of *Nitzschia*, and several other diatomaceous genera. The covering has a soft, felt-like appearance, is grayish or brownish in color, and does not seem to trouble the larvæ. An examination of the alimentary canal of *B. capitata* larvæ always revealed scores or hundreds of the siliceous tests of the diatoms. Undoubtedly the larvæ live chiefly on the diatoms which live on the rocks in these swift, clear waters. The sluggish habits of the larvæ, and their restriction to parts of the stream where the only other possible food is carried swiftly

along, makes this fixed diatom supply about the only food resource. In the Colorado and California larvæ of the *Bibiocephala* species and of *Blepharocera jordani*, the dorsal covering of diatoms is rather uncommon, though not infrequently to be seen.

Frequently the attempt has been made to bring living larvæ into the laboratory, but only when the collecting ground is very near the laboratory is this possible, and even then it is not worth while. The larvæ cannot live in stagnant or even in quiet or slow-running water. Indeed if, in the falling of the stream, larvæ get stranded in a suddenly made pool or still, quiet-water part of the stream they soon die. They must have the highly aërated, swift water of the stream's center; they like the lip of a fall, the rocks of cascades, and the sides of a pot-hole in which the water is ever whirling and boiling.

*Pupæ.*—The pupæ are found in the same places as the larvæ; that is, the larvæ when ready to pupate do little more than arrange themselves, almost always in small or large groups, with heads pointing down stream, and there make the last larval moult. Each pupa is fastened to the rocks by six pads, three on each lateral margin of the ventral aspect of the abdomen; these pads are not like the suckers of the larva whose hold can be voluntarily loosened, but they permanently attach the pupa to one spot. The pupa is strongly convex above, with a dark brown or black, heavily chitinized body-wall, and is perfectly flat on its ventral aspect, which lies smoothly against the rock. The wings and legs lie folded on this ventral aspect, which is covered only by a thin, colorless, pupal cuticula. From the prothorax projects dorsally a pair of respiratory organs, each composed of four thin, double-walled plates, the outer plates of each set being strongly chitinized and acting as protecting covers for the two delicate membranous inner ones (the whole arrangement like a two-leaved book with board covers).

Of absorbing interest to the observer is the course of emergence of the adult from its submerged, fixed pupal case. Professor Comstock seems to have been the first to

watch the process carefully, and he describes it in his Manual (p. 435) as follows:—

"Each midge on emerging forced its way out through a transverse rent between the thorax and abdomen. It then worked its body out slowly, and in spite of the swift current held it vertical. The water covering the patch of pupæ varied from one-fourth to one-half inch in depth. In the shallower parts the adult had no trouble in working its way to the surface, still clinging to the pupa-skin by its very long hind legs. While still anchored by its legs, the midge rests on the surface of the water for one or two seconds and unfolds its wings; then freeing its legs it takes flight. The adults emerging from the deeper water were swept away by the current before they had a chance to take wing. The time required for a midge to work its way out of the pupa-skin varied from three to five minutes."

As is obvious, the whole process of emergence and escape into free air must be a quick one. Usually with insects it takes some time for the proper expansion of the wings, which are, in the pupa, neither wider nor longer than the pupal wing-cases, but attain their full size only after withdrawal from these cases. But in the Blepharocerid there is no time for that; the slender legs cannot hold long against the beating of the swift water, and so the remarkable condition of a full development and expansion of the wings in the pupa obtains in this family. The fully developed wings lie in the pupal case folded both longitudinally and transversely, and only need to unfold to be ready to carry the fly into the safe air. It is this folding which produces the secondary veining of the wings characteristic of the family, this veining being simply the persisting creases and lines of the folding (Pl. XXI, figs. 7 and 8).

The writer has often watched the emergence of adults, and has been struck by the great loss (apparently) of life in the process. So many are swept away by the swift water before the wings can be unfolded or before the legs can be loosened from the pupal sheath, that it seems no wonder that the family is a disappearing one. It is a case of the

dangers of an extreme specialization. If the fixed pupæ lie in water too deep (easily occasioned by a sudden rise in the stream at the time for emergence), or on the other hand, become wholly bereft of the life-giving water by a falling of the stream, there is no hope for the fly. The first contingency seems indeed to be somewhat provided for (as explained in the account, *postea*, of the life-history of the flies) by the apparent power of the insect of postponing for some time, if necessary, its emergence. Thus, in the event of a heavy rain and consequent rise of the stream, the too deeply submerged pupa may lie unchanged until the water has run off (a matter which happens speedily in swift streams) to a safe shallowness.

*Imagines.*—The fully developed flies were found numerously in the case of but two of the six species whose larvæ and pupæ are familiar to the writer. These two are *Blepharocera capitata* (Ithaca, New York) and *Bibiocephala elegantulus* (Estes Park, Larimer County, Colorado). Abundant as the larvæ and pupæ of the Californian species are, and *Bibiocephala comstocki* and *B. doanei* are really abundant in half a dozen streams within easy reach of the laboratory, but one free-flying *B. comstocki* and but three or four *B. doanei* have been taken. Of *Blepharocera jordani*, whose larvæ and pupæ are also not uncommon in the same streams, but a single free fly has been taken. As indicated in the descriptions of the new species, it has been possible to get acquainted with the structural characters of the adults by dissecting the flies out from the pupal cases, but such methods are hardly available for a study of the habits of the flies!

The flies of *Blepharocera capitata* were seen abundant last summer (1901) on the banks of Cascadilla Creek, on Cornell University Campus (Ithaca, New York). The flies at rest cling by their long legs to the undersides of leaves on the bank, from the water's edge to eight or ten feet away. Of the hundreds of flies which were seen here in two or three visits, all were females; and the chief business on hand was feeding. This was accomplished by capturing

on the wing tiny Chironomid midges, and then returning to a leaf, where the unfortunate prey was lacerated by the long, strong, saw-like mandibles, and the blood and body juices drunk. The empty, torn skin of the prey was then dropped. As the males do not have the mandibles, they undoubtedly have a wholly different food habit (probably non-predatory), and this may account for the absence of males from this feeding ground. No indications could be found of mating or egg-laying. The flight is rather slow and weak, a sort of timid fluttering.

In the summers of 1900 and 1901 the flies of *Bibiocephala elegantulus* were seen commonly flitting about among the great boulders of the Willow Park terminal moraine, where the Big Thompson River cuts through it. The flies spent most of their time at rest on the vertical sides of the boulders from a few inches to two feet above the water's surface, but always where the rock face was frequently wetted by the spray of the dashing water. The flies rested with legs and wings outstretched and body close to the rock. The wings touched the rock face and, indeed, the attitude seemed to be adapted to bring as much of the body into contact with the wet smooth face of the rock as possible, as if to resist, by increased friction, the tendency of the fly to slide down the vertical surface. None of these flies was seen feeding, mating, or egg-laying, although many hours were spent in watching them. They were most numerous on bright, sunshiny days; on cloudy days the favorite rocks were often entirely deserted. The flight is poor, and numerous flies were caught readily in the hands.

*Life-history.*—The complete life-history of no Blepharocerid species is known. The eggs of no species are known, and the larvæ and pupæ of but two species not North American have been described, viz., *Philorus (Liponeura) brevirostris*, described by Dewitz and Wierzeijski from Europe, and *Curipara torrentium* described by Fritz Müller from Brazil.

The immature stages of one North American species, *Blepharocera capitata*, have been known since about 1881

Riley (1881) referring briefly to the finding of larvæ and pupæ of this species in Watertown, New York, and elsewhere later in that year. Comstock (1895) describes and figures both larvæ and pupæ, and in a comparatively recent paper (Kellogg, 1900) these stages were described in detail by the writer, and an account of the life-history of the species given as far as worked out. Young larvæ (2.5 millimeters long) were found abundantly in Coy Glen (Ithaca, New York) on May 9 (1898); on May 14, in the same place, the larvæ were from 3 to 10 millimeters (full grown) long, and the first pupæ were noted; on May 17, there were many new pupæ but also still many larvæ, and these of all sizes from the smallest to the full grown ones; on May 20, the pupæ far outnumbered the larvæ; and on May 26, the larvæ were scarce. No adults had yet issued. On June 1, the flies were found issuing, and by June 9, most of the imagines had issued although there were still pupæ and even some larvæ, mostly old. By the end of June, there were no larvæ or pupæ left. On June 27 (1901), the females were found in large numbers, feeding along Cascadilla Creek (Ithaca, New York), as already described. Both of these streams (Cascadilla and Coy Glen) have been watched by Professor Comstock through the latter half of the summer and autumn but no other generation appears. How long do the imagines live? When and where are the eggs laid?

On June 22 to 25, imagines of *Bibiocephala elegantulus* were found to be numerous among the boulders of Big Thompson stream, Estes Park, Colorado (altitude 7,500 feet), where the stream breaks through the Willow Park terminal moraine. At this time, old pupæ and empty pupal skins were found, but no larvæ except two very young ones. On August 10 to 12, the flies were found still common and numerous larvæ, young and old, but no pupæ. In three other nearby mountain torrents, viz., Wind Creek, Mill Creek, and South Fork of Big Thompson, adults and old pupæ were found. A note made at this time is as follows: "It seems to me that I have got here just as the last adults

of one generation are issuing, and that the larvæ of August are larvæ from eggs laid by these adults. This would mean a generation of flies appearing about July 1, say, and a second one appearing later, say about September 15." This is, of course, mere conjecture.

*Blepharocera jordani.* The larvæ of *Blepharocera jordani* have been found as early as February 23 (Los Gatos Creek, California), and as late as June 1 (Stevens Creek, California), and at various times in each of the three intervening months. Pupæ were first found on April 1 (Los Gatos Creek, California), and as late as June 4 (Smith's Creek, California). These dates are derived simply from the data of collected specimens and do not indicate a systematic inspection of any single breeding place of the species. On the occasion of the June captures, the larvæ were few and the pupæ old; on June 4, at Smith's Creek, only pupæ (*i. e.*, no larvæ) were found.

*Bibiocephala dōanei.* The larvæ of this species were taken as early as February 25 (Los Trancos Creek, California), and as late as July 26 (Red Cap Creek, Hoopa Indian Reservation, Humboldt County, California), and in all the intervening months; pupæ are first recorded March 31 (Campbell Creek, California) and from then till July 26 (Red Cap Creek, Humboldt County, California); the only free-flying imago was taken on July 15 (Congress Springs, Campbell Creek, California).

*Bibiocephala comstocki.* The writer's earliest recorded date of taking the larvæ of this species is February 11 (Alembique Creek, California), the latest April 30 (Stevens Creek, California); the earliest pupæ are of the date February 27 (Los Gatos Creek, California). A free-flying imago was taken April 6 (Saratoga Springs, Campbell Creek, California).

*Distribution.*—The Blepharoceridæ are too unfamiliar to allow us to make many generalizations yet regarding their distribution. What is known of the general distribution of

the family over the world has already been indicated in the Introduction and in the discussion of the classification of the genera. Although so few species are known, three continents are included in the range of the family, these conditions suggesting that we have to do with a family probably formerly including numerous species scattered over the world, but now dying out, a species persisting here and there through the wide range. These persisting species agree remarkably in the habits of the immature stages, and indicate in just what kind of habitat we should look for other members of the family in regions from which as yet no Blepharocerids are recorded. The larvæ and pupæ live shallowly submerged only in swiftly running, clear, fresh water; such conditions are provided by all, or nearly all, mountain or hill brooks and hardly anywhere else. As the known species extend from the equator to subarctic latitudes, temperature or climate offer probably no barriers, nor probably does altitude, the North American species ranging from nearly sea-level *(Blepharocera capitata)* to 8,000 feet *(Bibiocephala elegantulus)*.

In their local distribution those Blepharocerid species of which we know anything at all nearly sufficient for speaking with confidence, offer certain strikingly contrasting conditions. *Blepharocera capitata*, for example, specimens of which come from Ithaca, New York, from Ampersand Creek in the Adirondacks, and from Riviere des Chiens, a brook flowing into the St. Lawrence about twenty miles east of Quebec, and which has been taken in three or four other localities in northeastern United States and Canada, is common in three streams, Coy Glen, Six Mile Creek, and Cascadilla Creek, near Ithaca, New York. But there are at least a dozen other streams similarly swift, clear, and with smooth rock beds, within a radius of fifteen miles of Ithaca, and in most of these Professor Comstock and his students or the writer have looked for the species in vain. On the other hand, *Bibiocephala comstocki*, *B. doanei*, and *Blepharocera jordani*, first found by the writer in Los Gatos and Campbell creeks, near Stanford University, have since

been found in practically every one of the other eight or nine neighboring similar mountain streams which run down from the Santa Cruz and Santa Morena mountains eastward into the northern end of the Santa Clara Valley. And across the valley, fifty miles away to the south and east, the writer found two of these species in a stream (the Coyote) running from the Coast Range westward into the valley. Beyond, however, the mere facts of this contrasting local distribution, nothing can be offered here; we have not fairly begun to understand these strange and absorbingly interesting flies.

## VI. WORK TO BE DONE.

As this paper has been cast in its present form chiefly for the sake of serving as a sort of introduction to the study of the Blepharoceridæ by American students, this end will certainly only be furthered by calling specific attention to the most apparent desiderata in the knowledge of this group.

First, there are more species to be found in this country; wherever there are mountains or hills with swift, clear streams, it is safe to assert that Blepharoceridæ will be found there. Dipterologists have spoken to the writer of the rarity of these flies; but in an inspection of the region within twenty miles of his laboratory, every stream of a dozen was found to be invaded by the family, and in two years of unsystematic search as many more species have been added to the North American fauna as have been recorded since the first *Blepharocera capitata* was found in 1881. On a pleasure trip to Colorado, the four streams near the camping ground were all found inhabited by Blepharocerids; and in a careless stroll along the banks of the St. Lawrence, near Quebec, the characteristic larvæ were seen in the first brooklet peered into! Let the streams of the Ozarks, the Georgia hills, the Tennessee and North Carolina mountains, the Cascades and Olympics of the Puget Sound region, the Rockies of New Mexico and Arizona, and the mountains of Southern California be looked into.

With additional species and a widened distribution of old forms known, the classification can be revised and satisfactorily founded.

The life-history of no Blepharocerid species is fully known; the first eggs of any species are yet to be found; the food-habits of the males are unknown; a host of observations on the habits are to be made.

No one has studied the "secondary venation," the creasing of the wings. Are these lines of folding uniform in the species, genus, family? Are there classificatory characters to be derived from them? What is the significance of the little chitinous thickening or knot in the re-entrant angle of the anal margin of the wing?

Do the well developed and plainly differing external genitalia, especially those of the males, offer characters which can be used in classification? The writer is practically sure of this, and would have attempted to use them in the descriptions and analytical tables, only that nothing was known about them in the North American species previously described, and not yet seen by him.

NOTE.—The writer may add that he should like to have the opportunity to do some of this needed work, and to that end will be grateful for any sending of specimens, with full data, of larvæ, pupæ, or imagines of any species of Blepharocerid.

STANFORD UNIVERSITY,
CALIFORNIA,
November, 1902.

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## EXPLANATION OF PLATE XVIII.

*Blepharocera jordani*, sp. nov.

Fig. 1. Head of male.

*Blepharocera osten-sackeni*, sp. nov.

Fig. 2. Head of male.

*Bibiocephala doanei* KELLOGG.

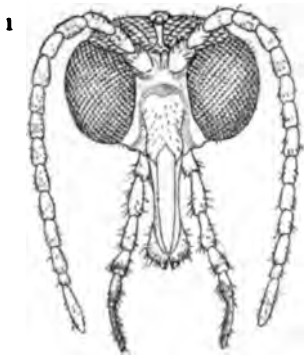
Fig. 3. Head of male.

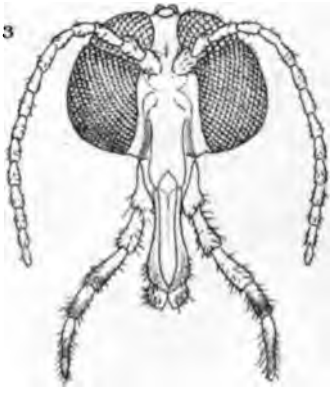
*Bibiocephala elegantulus* VON RÖDER.

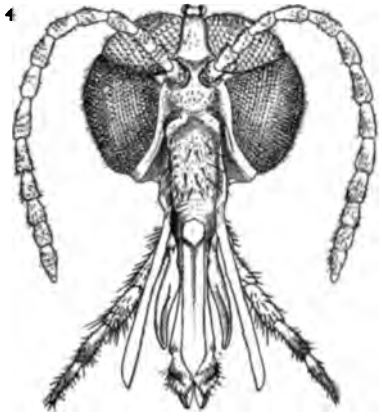
Fig. 4. Head of female.
Fig. 5. Head of male.

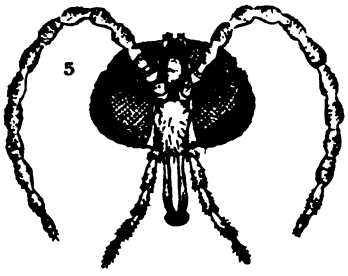
*Bibiocephala comstocki*, sp. nov.

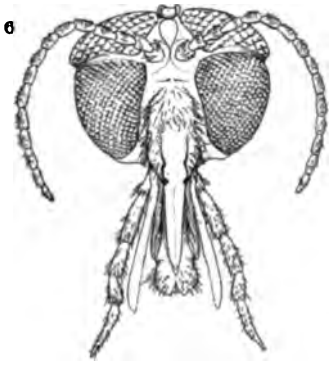
Fig. 6. Head of female.
Fig. 7. Head of male.

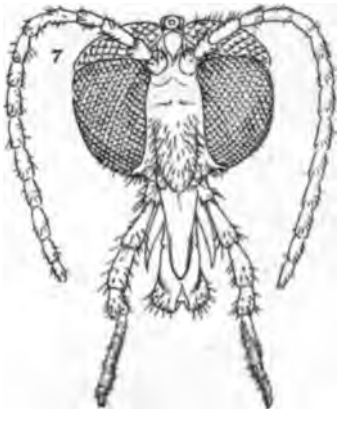


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## EXPLANATION OF PLATE XIX.

(Only the primary or true venation shown; the secondary venation, or lines of folding, omitted.)

*Blepharocera fasciata* LOEW.

Fig. 1. Wing (after Loew).

*Blepharocera osten-sackeni*, sp. nov.

Fig. 2. Wing (from specimen).

*Blepharocera jordani*, sp. nov.

Fig. 3. Wing (from specimen).

*Bibiocephala doanei* KELLOGG.

Fig. 4. Wing (from specimen).

*Bibiocephala elegantulus* VON RÖDER.

Fig. 5. Wing (from specimen).

*Bibiocephala comstocki*, sp. nov.

Fig. 6. Wing (from specimen).

*Bibiocephala grandis* OSTEN-SACKEN.

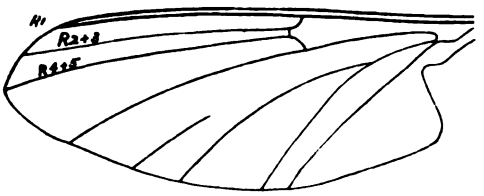
Fig. 7. Wing (after Osten-sacken).

*Philorus bilobata* LOEW.

Fig. 8. Wing (after Loew).

*Philorus yosemite* OSTEN-SACKEN.

Fig. 9. Wing (Diagram made from description of Osten-Sacken).

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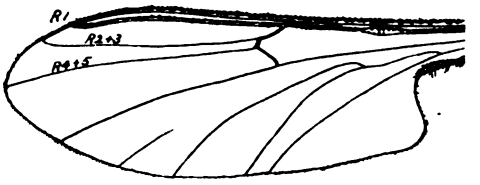


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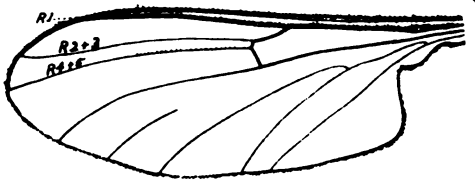


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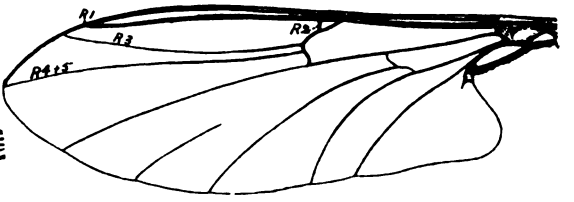


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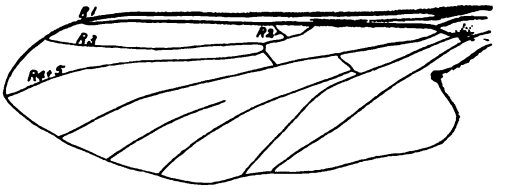


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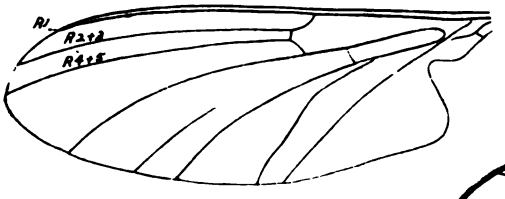


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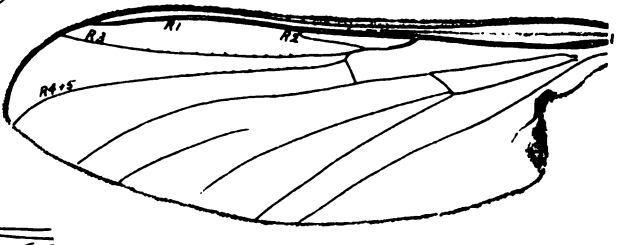


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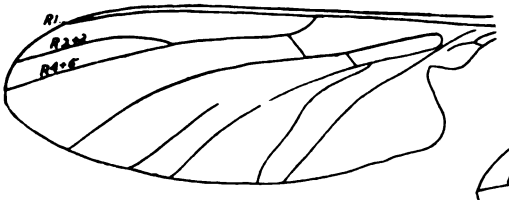


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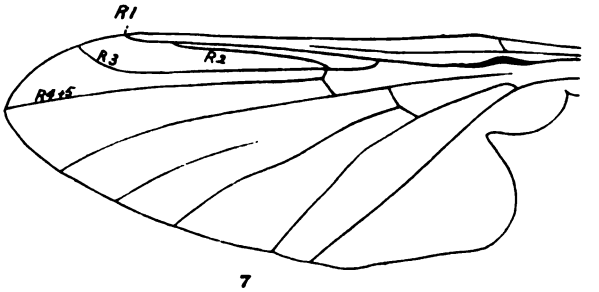


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## EXPLANATION OF PLATE XX.

*ant.*, antenna; *l. p.*, lateral process; *t. g.*, tracheal gills; *s.*, sucker.

*Blepharocera jordani*, sp. nov.

Fig. 1. Larva, dorsal aspect.
Fig. 2. Larva, ventral aspect.

*Blepharocera osten-sackeni*, sp. nov.

Fig. 3. Larva, dorsal aspect.
Fig. 4. Larva, ventral aspect.

*Bibiocephala comstocki*, sp. nov.

Fig. 5. Larva, dorsal aspect.
Fig. 6. Larva, ventral aspect.

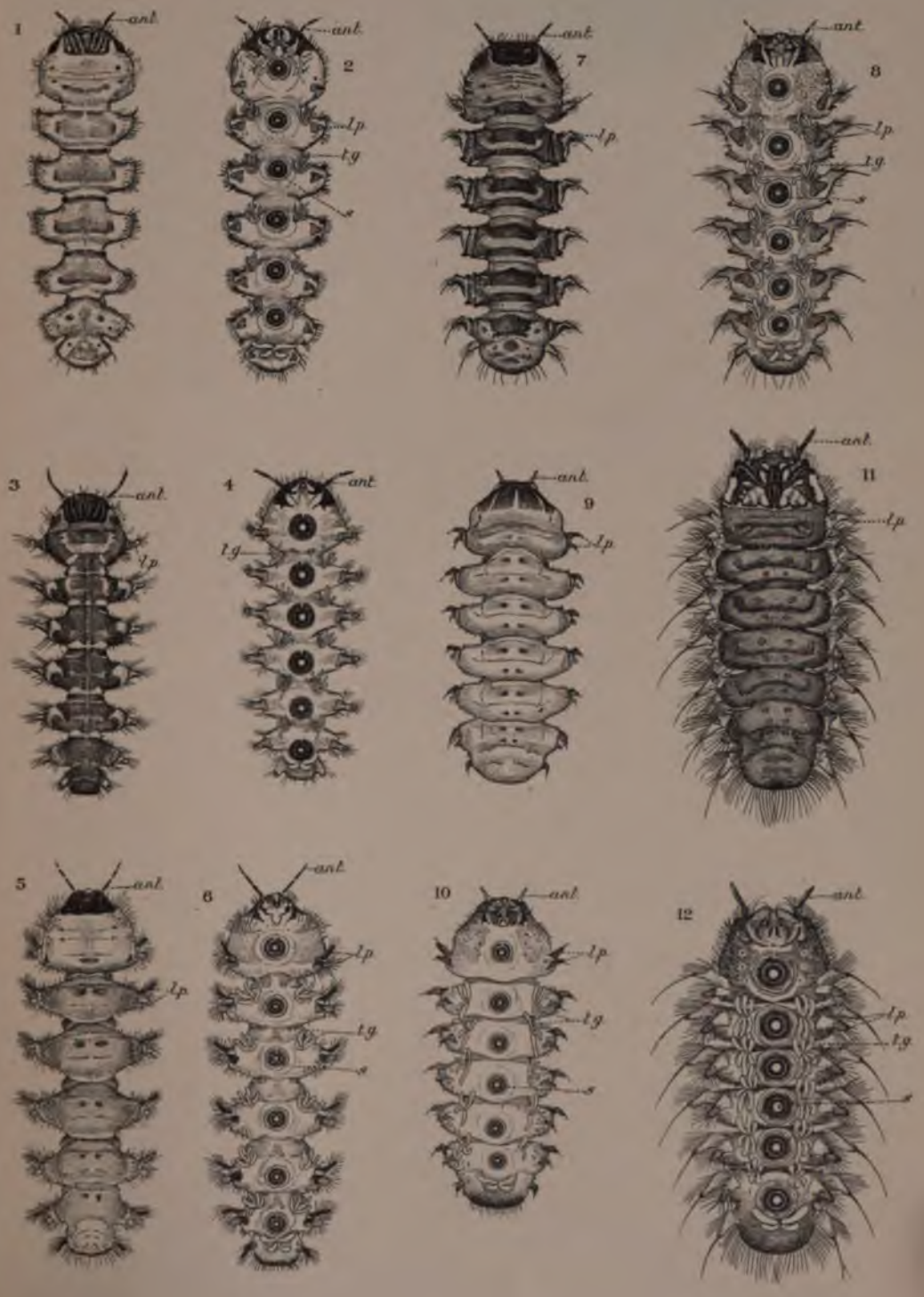
*Bibiocephala doanei* KELLOGG.

Fig. 7. Larva, dorsal aspect.
Fig. 8. Larva, ventral aspect.

*Bibiocephala elegantulus* VON RÖDER.

Fig. 9. Larva, dorsal aspect.
Fig. 10. Larva, ventral aspect.

Fig. 11. Larva from Colorado, unknown species; dorsal aspect.
Fig. 12. Larva from Colorado, unknown species; ventral aspect.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## EXPLANATION OF PLATE XXI.

Fig. 1. Larva from California, unknown species; dorsal aspect.
Fig. 2. Larva from California, unknown species; ventral aspect.

*Bibiocephala doanei* KELLOGG.

Fig. 3. Pupa, dorsal aspect.

*Bibiocephala comstocki*, sp. nov.

Fig. 4. Pupa, dorsal aspect.

*Blepharocera capitata* LOEW.

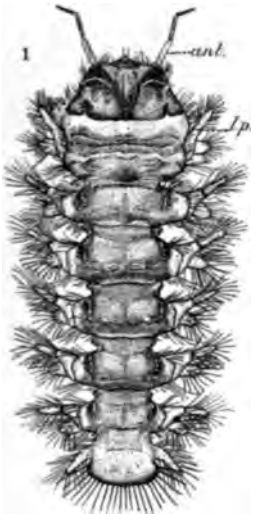
Fig. 5. Sucker of larva, ventral aspect.
Fig. 6. Cross-section through body of larva, showing structure and mechanism of sucker: *h.*, heart; *al. c.*, alimentary canal; *v. c.*, ventral nerve chain; *l. p.*, lateral process; *msc.*, muscles; *st.*, "stopper" of sucker; *t.*, tendon; *r.*, rim of sucker.

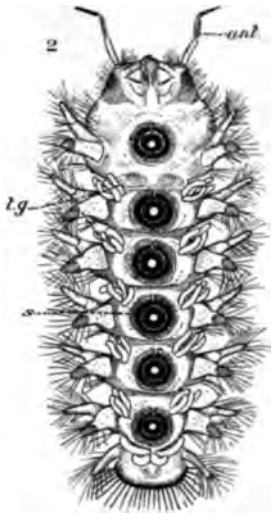
*Bibiocephala elegantulus* VON RÖDER.

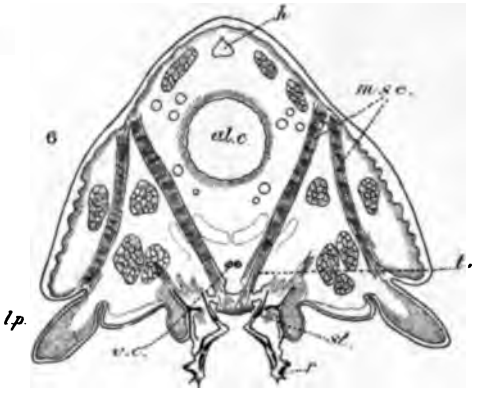
Fig. 7. Adult female.

*Blepharocera capitata* LOEW.

Fig. 8. Adult male.





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## EXPLANATION OF PLATE XXII.

*Blepharocera capitata* LOEW.

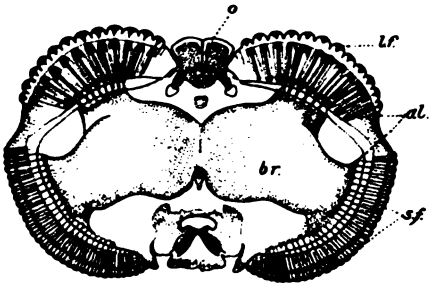
Fig. 1. Section through the compound eye of adult female: *o.*, ocelli; *br.*, brain; *l. f.*, large facets; *s. f.*, small facets; *o. l.*, optic lobes.
Fig. 2. Dorsal plate of male genitalia.
Fig. 3. Ventral plate of male genitalia.
Fig. 4. Genitalia of female, dorsal aspect.
Fig. 5. Papillæ, enlarged, on female genitalia.
Fig. 6. Genitalia of female, ventral aspect.

*Bibiocephala elegantulus* VON RÖDER.

Fig. 7. Genitalia of female, ventral aspect.
Fig. 8. Genitalia of male, ventral aspect.

*Bibiocephala doanei* KELLOGG.

Fig. 9. Mouth-parts of female: *l. ep.*, labrum-epipharynx; *md.*, mandibles; *mx. l.*, maxillary lobe; *mx. p.*, maxillary palpus; *hyp.*, hypopharynx; *li.*, labium; *pg.*, paraglossa.
Fig. 10. Mouth-parts of female in cross-section, near the base, diagrammatic; letters as for fig. 9 except *lb.*, labrum-epipharynx.
Fig. 11. Mouth-parts of female in cross-section, near tip, diagrammatic; letters as for fig. 10.

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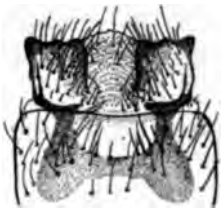

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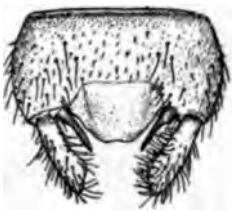

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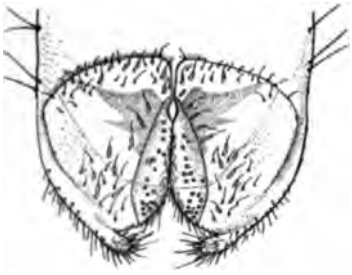

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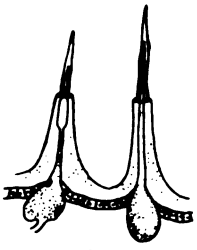

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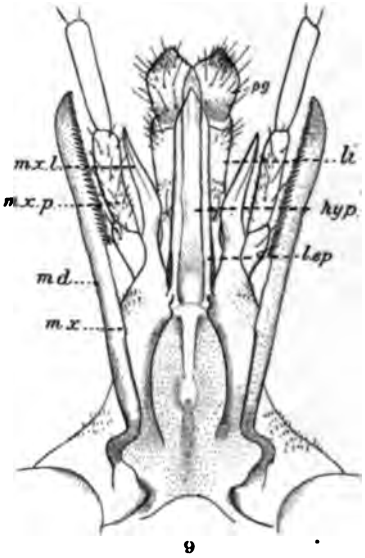


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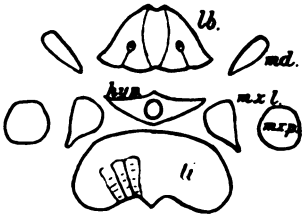


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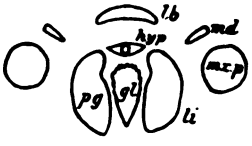


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PHOTO-LITH. PRITTON & REY. S.F.

PAPERS FROM THE HOPKINS STANFORD GALAPAGOS EXPEDITION, 1898–1899.

# MAMMALS OF THE GALAPAGOS ARCHIPELAGO, EXCLUSIVE OF THE CETACEA.

BY EDMUND HELLER.

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## INTRODUCTION.

The present paper is based on a small collection of mammals obtained by the Hopkins Stanford Galapagos Expedition at the Galapagos Archipelago.

The members of the expedition, Mr. Robert E. Snodgrass and the author, through the patronage of Mr. Timothy Hopkins of San Francisco, and under the auspices of the Department of Zoology of Stanford University, accompanied the sealing schooner Julia E. Whalen on a ten months' cruise among the Galapagos Islands. Every

island of the group was visited, and collections of the fauna and flora were made at each one. A special effort was made to obtain all the species of indigenous terrestrial Mammalia.

## FAUNAL DERIVATION.

The affinities of the Mammalia appear to be entirely with South American forms. *Nesoryzomys*, the only peculiar genus, is most closely related to *Oryzomys*. The affinities of the two species of *Oryzomys* which occur in the archipelago are not yet known or determined, but the genus is chiefly Neotropical. The single species of *Lasiurus* is very closely allied to a Chilean species. The hair-seal *Otaria* is a widespread species of antarctic derivation, reaching its northern limits in the Galapagos Archipelago. The fur-seal *Arctocephalus* is a peculiar species, but is evidently of antarctic derivation also, its affinities being with *A. philippi* of Juan Fernandez. A South American derivation of the Mammalia south of the Equator would be favored by the direction of the existing ocean currents and winds, and it is probable that these agencies are responsible for the present distribution of mammals on the islands. The evidence, however, of the relationships of several other groups, especially the birds and flora, favors a Central American derivation with only a slight South American element; but this may be due to the greater antiquity of such forms in the archipelago.

## DISTRIBUTION.

The genera *Oryzomys* and *Nesoryzomys* are known only from Chatham, Barrington, Indefatigable, Seymour, and Narborough islands. Leaving out of consideration Albemarle, James, Charles, and Duncan, the islands which are inhabited by introduced species, it seems remarkable that large islands like Abingdon, Bindloe, and Hood should lack indigenous species of Muridæ. A careful search, however, failed to discover any mammals on these islands. It is

probable that James, Duncan, and Albemarle islands, intervening between the ranges of the two species of *Nesoryzomys*, were until recently inhabited by indigenous species of this genus which became extinct upon the introduction of *Mus*. *Oryzomys* is doubtless the older genus, and occurs, as a natural consequence, on one of the weather islands, Chatham, from which it has apparently spread to Barrington.

The author is under obligation to Mr. R. E. Snodgrass for the measurements of seals in the flesh, to Mr. W. H. Osgood of the U. S. Biological Survey for Waterhouse's account of *Mus galapagoensis*, and to Mr. A. H. Baldwin for the drawings of skulls.

## DESCRIPTION OF SPECIES.

### Family MURIDÆ.

#### **Mus** *Linnæus.*

*Mus* Linnæus, Syst. Nat. VI, 1766, p. 83.

*Type*, *Mus rattus* Linn.

*Range*.—Cosmopolitan. Indigenous in Eurasia and Africa. Galapagos Archipelago (three species of wide distribution).

#### **Mus rattus** *Linnæus.*

*Mus rattus* Linn. Syst. Nat. VI, 1766, p. 83.

*Range*.—Cosmopolitan. Indigenous in Asia Minor. Galapagos Archipelago: Albemarle Island (Baur, Hopkins Expedition), Duncan Island (Baur, Hopkins Expedition), Chatham Island (Hopkins Expedition).

We may safely assume that *Mus rattus* has been an inhabitant of the archipelago nearly as long as *M. alexandrinus*, which was first reported by Darwin on James Island in 1835. On Chatham Island, and at Iguana Cove and Elizabeth Bay, Albemarle Island, *Mus rattus* is better established than *M. alexandrinus*. The introduction of *M. rattus* on Chatham Island is perhaps more recent, as it was not observed by Darwin, who collected *Oryzomys galapagoensis* there.

A considerable series of specimens is in the collection from Iguana and Tagus coves and Elizabeth Bay, Albemarle Island; Wreck Bay, Chatham Island; and Duncan Island. From the last locality this is the only known rodent, but on Albemarle and Chatham it occurs with *M. alexandrinus*, with which form it apparently intergrades in both coloration and skull characters. In no locality in the archipelago do any species of *Mus* occur with the indigenous species of *Oryzomys* and *Nesoryzomys*. This is probably due to the extermination of these latter species by hardier introduced forms of *Mus*, and by cats.

MEASUREMENTS OF MUS RATTUS.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Locality | Total length | Tail vertebræ | Hind foot | Ear |
|---|---|---|---|---|---|---|
| 2374 | ad. ♂ | Iguana Cove, Albemarle Island | 426 | 231 | 35 | 25 |
| 2375 | " " | " " " " | 411 | 215 | 35 | 24 |
| 2376 | " " | " " " " | 407 | 226 | 35 | 22 |
| 2377 | " " | " " " " | 392 | 208 | 33 | 22.5 |
| 2378 | " " | " " " " | 366 | 195 | 31 | 22 |
| 2379 | " " | " " " " | 367 | 192 | 35 | 21 |
| 2386 | " " | Tagus " " " | 355 | 170 | 34 | 24 |
| 2387 | " " | " " " " | 377 | 212 | 33 | 24 |
| 2388 | " " | " " " " | 419 | 233 | 36 | 25 |
| 2392 | " " | Elizabeth Bay " " | 380 | 216 | 35 | 24 |
| 2394 | " " | Wreck Bay, Chatham Island | 402 | 230 | 35 | 25 |
| 2396 | " " | " " " " | 409 | 222 | 35 | 24 |
| 2397 | " " | " " " " | 413 | 230 | 36 | 25 |
| 2410 | " " | Duncan Island | 398 | 214 | 34 | 23 |
| 2411 | " " | " " | 362 | 191 | 34 | 24.5 |
| 2380 | " ♀ | Iguana Cove, Albemarle Island | 405 | 213 | 35 | 22 |
| 2381 | " " | " " " " | 405 | 215 | 35 | 23 |
| 2389 | " " | Tagus " " " | 436 | 206 | 33 | 24 |
| 2390 | " " | " " " " | 390 | 226 | 34 | 25 |
| 2391 | " " | " " " " | 380 | 210 | 34 | 25 |
| 2393 | " " | Elizabeth Bay " " | 381 | 212 | 33 | 22 |
| 2400 | " " | Wreck Bay, Chatham Island | 412 | 220 | 35 | 25 |
| 2401 | " " | " " " " | 415 | 228 | 35 | 25 |
| 2402 | " " | " " " " | 366 | 193 | 33 | 24 |
| 2403 | " " | " " " " | 385 | 214 | 36 | 23 |
| 2412 | " " | Duncan Island | 443 | 226 | 33 | 25 |

## Mus alexandrinus *St. Hilaire.*

*Mus alexandrinus* St. Hil. Descr. Egypt, v. 2, 1815, p. 733.
*Mus jacobiæ* Waterh. Zool. Voy. Beagle, v. 1, pt. 2, 1840, p. 34.
*Mus decumanus* Allen, Bull. Am. Mus. Nat. Hist. v. 4, 1892, p. 48.

*Range.*—Cosmopolitan in temperate and tropical regions. Indigenous in western Asia. Galapagos Archipelago: Albemarle Island (Baur, Hopkins Expedition), James Island (Darwin, Hopkins Expedition), Chatham Island (Hopkins Expedition), Charles Island (Hopkins Expedition).

Galapagos specimens show somewhat shorter tails than typical *alexandrinus*, but, as in that species, the annuli on a perfect tail are usually about two hundred forty in number. The tail is much less hairy, the tympanic portion of the skull is conspicuously larger, and the coloration of the upper parts is less reddish than in *decumanus (norvegicus)*, to which species Allen referred his mummified specimen.

Specimens from James Bay, James Island, are larger and more uniform in coloration than those from any of the other islands. Albemarle specimens average small. Those secured at Tagus Cove, Albemarle, are lighter above and more sulphur-yellow below. Specimens from the moist portions of the archipelago, as Iguana Cove, Albemarle Island, and Wreck Bay, Chatham Island, are dark and approach or intergrade in coloration with *Mus rattus*.

The skulls agree essentially with those of *Mus rattus*. They differ considerably from California and Cocos Island[1] specimens of *M. norvegicus*. The tympanic bullæ are larger and not so far apart, the basi-occipital and basi-sphenoid bridges being considerably narrower.

This is the most abundant rat wherever it occurs. It ranges widely, occurring from sea-level to the rims of the highest craters.

[1] Four specimens of *M. norvegicus* were taken at Cocos Island, July 3, 1899. These are similar in coloration to continental forms, but are somewhat smaller. The largest male measures: Total length 393 mm., tail vertebræ 183 mm., hind foot 35 mm., ear 20.5 mm.

MEASUREMENTS OF MUS ALEXANDRINUS.

| L. S. Jr. U. Zool. Coll. No. | Age and Sex | Locality | Total length | Tail vertebræ | Hind foot | Ear |
|---|---|---|---|---|---|---|
| 2432 | ad. ♂ | James Island | 417 | 228 | 35 | 25 |
| 2415 | " " | Tagus Cove, Albemarle Island | 343 | 190 | 31 | 22 |
| 2416 | " " | " " " " | 395 | 225 | 36 | 24 |
| 2418 | " " | " " " " | 350 | 186 | 33 | 23.5 |
| 2419 | " " | " " " " | 383 | 212 | 33 | 24 |
| 2420 | " " | " " " " | 373 | 192 | 33 | 24 |
| 2421 | " " | " " " " | 328 | 180 | 30 | 20 |
| 2422 | " " | " " " " | 353 | 172 | 37 | 25 |
| 2423 | " " | " " " " | 351 | 195 | 36 | 23.5 |
| 2433 | " ♀ | James Island | 398 | 218 | 35 | 24 |
| 2434 | " " | " " | 464 | 253 | 36 | 27 |
| 2435 | " " | " " | 398 | 215 | 34 | 23 |
| 2436 | " " | " " | 445 | 248 | 34 | 23 |
| 2424 | " " | Tagus Cove, Albemarle Island | 391 | 208 | 33 | 21 |
| 2425 | " " | " " " " | 394 | 225 | 35 | 25.5 |
| 2426 | " " | " " " " | 362 | 208 | 34 | 24.5 |
| 2427 | " " | " " " " | 378 | 215 | 32 | 25 |
| 2430 | " " | Chatham Island | 380 | 210 | 32 | 25 |
| 2431 | " " | " " | 385 | 208 | 33 | 25.5 |
| 2437 | " " | Charles " | 379 | 200 | 31 | 23.5 |

## Mus musculus *Linnæus*.

*Mus musculus* Linn. Syst. Nat. 1766, p. 83.

*Range*.—Cosmopolitan. Indigenous in Asia. Galapagos Archipelago: Chatham Island (Hopkins Expedition).

Five specimens were secured at Wreck Bay, Chatham Island, about the warehouses, where they have doubtless been recently introduced from Ecuadorian vessels, as they have not yet spread to the uninhabited portions of the island.

Our specimens are somewhat different in coloration from typical *M. musculus*. The brownish of the upper parts is largely mixed with reddish, the under parts are light ashy gray washed with brownish fulvous, and the feet are white above.

MEASUREMENTS OF MUS MUSCULUS.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | LOCALITY | Total length | Tail vertebræ | Hind foot | Ear |
|---|---|---|---|---|---|---|
| 2438 | ad. ♂ | Wreck Bay, Chatham Island | 168 | 77 | 17 | 14 |
| 2441 | " " | " " " " | 167 | 76 | 18 | 13 |
| 2442 | " " | " " " " | 146 | 72 | 17 | 13 |
| 2442 | " ♀ | " " " " | 172 | 81 | 16 | 15 |

## Oryzomys *Baird.*

*Oryzomys* Baird, N. Am. Mamm. 1857, p. 458.

*Type, Mus palustris* Harlan.

*Range.*—Southeastern United States from New Jersey south through Mexico, West Indies, and Central and South America to Patagonia. Galapagos Archipelago (two peculiar species).

## Oryzomys galapagoensis *(Waterhouse).*

*Mus galapagoensis* Waterh. Zool. Voy. Beagle, Mamm. 1839, p. 65.

*Range.*—Chatham Island (Darwin).

This species has not been collected since Darwin took the types in 1835. It is now probably extinct or else restricted to the barren eastern part of the island where Darwin secured his specimens.

Measurements[1] of the type (dried skin): Total length 272, tail vertebræ 120, hind foot 30, ear 15; length of skull 31, width 16.

## Oryzomys bauri *Allen.*

*Oryzomys bauri* Allen, Bull. Am. Mus. Nat. Hist. v. 4, 1892, p. 48.

*Range.*—Barrington Island (Baur, Hopkins Expedition).

This species is very closely allied to *O. galapagoensis*, differing mainly in having a somewhat shorter tail and less yellow on the upper parts.

[1] Waterhouse, Zool. Voy. Beagle, Mamm. 1839, p. 65.

It is unfortunate that we have no specimens of the Chatham Island species for comparison, as good differences no doubt exist; but owing to the nature of the type description, exact comparison is impossible. The differences (shorter tail and ears) given by Allen cannot be relied upon, as Waterhouse's measurements were evidently taken from a dried skin and are not comparable with those of Allen's alcoholic specimens. Our measurements in the flesh are also of little value in this connection.

We found this mouse very abundant on Barrington Island. It was found inhabiting crevices among the loose lava rocks and burrows and runways beneath bushes and brush piles. In habits it appears to be somewhat diurnal and was as often seen at midday as at other times.

MEASUREMENTS OF ORYZOMYS BAURI.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Locality | Total length | Tail vertebræ | Hind foot | Ear |
|---|---|---|---|---|---|---|
| 2443 | ad. ♂ | Barrington Island | 289 | 141 | 31 | 21.5 |
| 2444 | " " | " " | 258 | 128 | 30 | 21 |
| 2445 | " " | " " | 291 | 151 | 31.5 | 22 |
| 2446 | " " | " " | 268 | 136 | 30 | 18 |
| 2447 | " " | " " | 261 | 132 | 30 | 22 |
| 2448 | " " | " " | 298 | 150 | 31 | 21.5 |
| 2449 | " " | " " | 289 | 144 | 31 | 21 |
| 2450 | " " | " " | 276 | 135 | 31 | 22 |
| 2451 | " ♀ | " " | 235 | 120 | 29 | 20.5 |
| 2452 | " " | " " | 245 | 120 | 29 | 21.5 |
| 2453 | " " | " " | 292 | 137 | 30.5 | 22 |

MEASUREMENTS OF SKULLS.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Occipito-nasal length | Greatest zygomatic breadth | Nasals, length | Nasals, width | Interorbital width | Diastema | Length of palatal foramen | Length of upper molar series |
|---|---|---|---|---|---|---|---|---|---|
| 2447 | ad. ♂ | 31 | 16 | 12.5 | 4 | 5.2 | 7.5 | 6 | 6 |
| 2446 | " " | 32 | 16.5 | 13 | 4 | 5.2 | 8 | 6.5 | 6 |
| 2444 | " " | 30.5 | 16 | 12 | 4 | 5.2 | 7 | 6.3 | 6 |
| 2448 | " " | 34 | 18 | 13.5 | 4 | 6 | 8.5 | 7 | 6 |
| 2445 | " " | 33 | 18 | 13.5 | 4 | 5.5 | 8 | 7 | 6 |
| 2452 | " ♀ | 29.5 | 15.5 | 12.5 | 4 | 5.2 | 7 | 6 | 6 |

## **Nesoryzomys** new genus.

Similar to *Oryzomys*, but interorbital portion of skull very different. The frontal bones medially much narrower, with rounded sides at the interorbital constriction; snout more elongate, the nasals narrower, considerably longer, and less convex in profile; zygomatic width of skull and length of upper molar series much less. The external differences in Galapagos species consist of considerably shorter fur and tail.

*Type*, *N. narboroughi*.

*Range*.—Galapagos Archipelago (two peculiar species).

## **Nesoryzomys indefessus** (*Thomas*).

*Oryzomys indefessus* Thomas, Ann. and Mag. Nat. Hist. ser. 7, v. 4, 1899, p. 280.

*Range*.—Indefatigable Island (Rothschild Expedition, Hopkins Expedition), South Seymour Island (Hopkins Expedition).

An abundant species on Indefatigable Island and South Seymour Island, but lacking on North Seymour. This species seems to be more nocturnal in habits than *Oryzomys*. It inhabits burrows or rock crevices beneath bushes.

MEASUREMENTS OF NESORYZOMYS INDEFESSUS

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Locality | Total length | Tail vertebræ | Hind foot | Ear |
|---|---|---|---|---|---|---|
| 2459 | ad. ♂ | South Seymour Island | 244 | 98 | 27 | 21 |
| 2460 | " " | " " " | 258 | 108 | 28.5 | 22 |
| 2461 | " " | " " " | 264 | 108 | 29 | 21.5 |
| 2462 | " " | " " " | 269 | 108 | 29 | 22 |
| 2463 | " " | Indefatigable Island | 270 | 113 | 28 | 21.5 |
| 2464 | " " | " " | 258 | 100 | 27 | 20 |
| 2454 | " ♀ | South Seymour Island | 243 | 99 | 26 | 20 |
| 2455 | " " | " " " | 252 | 101 | 26 | 21 |
| 2456 | " " | " " " | 244 | 101 | 28 | 21 |
| 2457 | " " | " " " | 242 | 102 | 26 | 22 |
| 2458 | " " | " " " | 248 | 101 | 27.5 | 22 |
| 2465 | " " | Indefatigable Island | 285 | 115 | 27 | 22 |
| 2466 | " " | " " | 260 | 103 | 27 | 21 |

MEASUREMENTS OF SKULLS.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Occipito-nasal length | Greatest zygomatic breadth | Nasals, length | Nasals, width | Interorbital width | Diastema | Length of palatal foramen | Length of upper molar series |
|---|---|---|---|---|---|---|---|---|---|
| 2460 | ad. ♂ | 37 | 18 | 17 | 4 | 4 | 9·7 | 7 | 5·2 |
| 2466 | " " | 36·5 | 19·3 | 17 | 3·7 | 4 | 10 | 7 | 5·5 |
| 2462 | " " | 37·5 | 19 | 16·5 | 4 | 4·5 | 9·8 | 7 | 5·7 |
| 2463 | " " | 39 | 19 3 | 16·5 | 4 | 4·5 | 10 | 7·3 | 6·3 |
| 2465 | " " | 37 | 19 | 16·5 | 3·8 | 4·3 | 10 | 7·3 | 6 |
| 2464 | " ♀ | 36·5 | 18·5 | 15·5 | 3·7 | 4 | 9·3 | 7 | 5·5 |
| 2461 | " " | 39 | 21 | 17 | 4 | 4·5 | 10 | 7·5 | 6·3 |

## **Nesoryzomys narboroughi** new species.

*Type*, adult male, No. 2470, Leland Stanford Junior University Zool. Coll.; Narborough Island, April 3, 1899.

*Range*.—Narborough Island (Hopkins Expedition).

*Specific characters*.—Similar to *N. indefessus* but larger, feet and ears especially larger, the former 31 mm. or greater in length; coloration much darker above, chiefly blackish mixed with some rusty brownish, below darker gray.

*Coloration*.—Above blackish, much mixed with rusty and yellowish brown, sides becoming more yellowish brown; below drab-gray, the hairs plumbeous at the base; sides of head like sides of body, a blackish spot below eye; fur bordering the lips white; tail above dusky black, below drab-gray like the belly; feet white, ears thinly covered externally with brownish hairs.

*Cranial characters*.—Skull like that of *N. indefessus* but distinguishable by the considerably greater width, longer nasals, and shorter palatal foramen.

*Measurements*.—Type, adult male: Total length 303 mm., tail vertebræ 131 mm., hind foot 33 mm., ear 23 mm. Average of the three adult males: Total length 292 mm., tail vertebræ 124 mm., hind foot 32 mm., ear 23 mm.

This species was found inhabiting the cracks and fissures in barren black lava fields near the coast of Mangrove Point, Narborough Island. Individuals were rather scarce at this locality, perhaps owing to the paucity of the vegetation. The contents of several stomachs were examined and found to contain a reddish material resembling pulverized Crustaceæ.

MEASUREMENTS OF NESORYZOMYS NARBOROUGHI.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Locality | Total length | Tail vertebræ | Hind foot | Ear |
|---|---|---|---|---|---|---|
| 2468 | ad. ♂ | Mangrove Point, Narborough Island | 292 | 120 | 33 | 23 |
| 2469 | " " | " " " " | 282 | 120 | 31 | 23 |
| 2470 | " " | " " " " | 303 | 131 | 33 | 23 |
| 2471 | " ♀ | " " " " | 262 | 123 | 33 | 20.5 |
| 2472 | " " | " " " " | 282 | 121 | 31 | 23.5 |
| 2473 | " " | " " " " | 299 | 126 | 32.5 | 22 |
| 2474 | " " | " " " " | 276 | 120 | 30 | 22 |

MEASUREMENTS OF SKULLS.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Occipito-nasal length | Greatest zygomatic breadth | Nasals, length | Nasals, width | Interorbital width | Diastema | Length of palatal foramen | Length of upper molar series |
|---|---|---|---|---|---|---|---|---|---|
| 2470 | ad. ♂ | 41.5 | 20 | 17 | 4.5 | 4 | 11 | 7 | 5.5 |
| 2469 | " " | 37.5 | 18 | 15 | 4 | 4.3 | 9.7 | 7 | 6 |
| 2468 | " " | 40 | 20 | 17.5 | 4.5 | 5 | 10 | 6.8 | 5.7 |
| 2471 | " ♀ | 35.5 | 17.5 | 14.5 | 3.7 | 4.7 | 9 | 6.5 | 6 |
| 2472 | " " | 39.5 | 19 | 16.2 | 4 | 4.5 | 9.7 | 7 | 6 |
| 2474 | " " | 38.5 | 18.5 | 16 | 4 | 4 | 10 | 6 | 5.5 |
| 2473 | " " | 39 | 19.5 | 15.5 | 4.5 | 4.5 | 10 | 7 | 5.5 |

## Family OTARIIDÆ.

### Otaria *Péron.*

*Otaria* Péron, Voy. aux Terr. Auste. v. 2, 1816, p. 37.

*Range.*—Galapagos Archipelago and coast of Peru southward to Cape Horn; Atlantic coast of South America north to La Plata.

### Otaria jubata *(Forster.)*

*Phoca jubata* Forst. Description Anim. 1775, pp. 66, 317.
*Otaria byroni* Blainv. Journ. Phys. v. 91, 1820, p. 287.
*Otaria jubata* Allen, U. S. Geol. and Geog. Sur. Misc. Pub. v. 12, 1880, p. 208.

*Range.*—Same as that of the genus. Observed on all the islands of the Galapagos Archipelago (Hopkins Expedition).

Two adult skins and one immature skull are in the collection from Albemarle and Narborough Islands.

This is the most abundant seal in the archipelago and breeds wherever found. The breeding season does not appear to be confined to any definite time of year, as pups of all ages were found at all the rookeries during our stay of six months. January, February, and March, 1899, were spent about the rookeries on Narborough Island, and Elizabeth Bay, Albemarle Island; April, at the Seymour Islands; and May, at Hood and Barrington islands. The pups at all these localities were found to be of various ages.

The most extensive rookeries are situated on the east coast of Narborough Island, at Elizabeth Bay, Albemarle Island, at Gardner Bay, Hood Island, at the Seymour Islands, and on Barrington Island. The largest rookeries are on Narborough Island. These are situated along the whole east coast for a distance of about fifteen miles. This stretch of coast is well sheltered, deeply indented by lagoons and covered in many places by a heavy growth of mangrove, thus forming ideal breeding grounds for *Otaria*. The extensive rookeries at Elizabeth Bay are similarly situated on mangrove-fringed lagoons in quiet water.

The bulls do not appear to be polygamous, a bull being usually associated with but a single cow. This apparent absence of polygamy may be due to the lack of a definite breeding season.

In most localities the seals are fearless, and the cows and pups allow themselves to be herded like cattle. So abundant and tame are they that the five sailors comprising the sealing crew of our schooner took twenty-one hundred skins in about four months. Usually as many skins as could be "flinched" in a day could be readily obtained.

The sharks, chiefly the genera *Carcarhinus* and *Galeocerdo*, are the worst enemies the seals have to contend with. Their depredations are confined largely to the pups, though the latter genus is a serious menace even to the adults.

While the crew were engaged in collecting shark fins, we had an opportunity of dissecting a large number of sharks, and found that a majority of those caught contained the remains of seals, chiefly pups.

From our observations the horse mackerel *Thunnus thynnus* appears to form a considerable part of the food of the seals.

The coloration of the wet skin of an adult female was as follows: Dorsum from eyes to base of tail dusky gray minutely mottled with light yellowish; sides and underside of neck, sides of body, region about ears and base of vibrissæ light yellowish brown; entire under parts posterior to fore-flippers brown; ears yellowish at base, grayish posteriorly, with dusky tips; nose black; vibrissæ pale. Another adult female was similar to the above but sides of head and rump extensively brown.

MEASUREMENTS OF OTARIA JUBATA.

| Age and sex | Locality | Total length | Tail vertebræ | Snout to shoulder | Snout to ear | Snout to eye | Width at shoulders | Width at ears | Interorbital width | Ear | Length of vibrissæ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ad. ♀ | Narborough Island | 1137 | 71 | 575 | 162 | 87 | 362 | 112 | 75 | 31 | 150 |
| " " | " " | 1437 | 81 | 725 | 200 | 93 | 425 | 162 | 81 | 31 | 131 |
| " " | " " | 1350 | 71 | 687 | 175 | 81 | 425 | 150 | 87 | 31 | 156 |

## Arctocephalus *Cuvier*.

*Arctocephalus* Cuvier, Mem. du Mus. d'Hist. Nat. v. 11, 1824, p. 205.

*Range*.—South African, Australian, and Antarctic regions; coasts of South America from Cape Horn north to Rio Janeiro, and Guadalupe Island, Lower California.

## Arctocephalus galapagoensis new species.

*Arctocephalus australis* Allen, U. S. Geol. and Geog. Sur. Misc. Pub. v. 12, 1880, p. 210.

*Arctocephalus philippi* Jordan, Rept. Fur Seal Investig. Wash. pt. 3, 1899, p. 272.

*Type*, adult male, skull no. 2480, Leland Stanford Junior University Zool. Coll.; Wenman Island.

*Range.*—Galapagos Archipelago; Culpepper Island (Hopkins Expedition), Wenman Island (Hopkins Expedition), Albemarle Island (Hopkins Expedition), Tower and Abingdon Islands (various sealing expeditions).

*Specific characters.*—Distinguishable from its nearest ally *A. philippi* of Juan Fernandez by its wider skull, both the zygomatic and mastoid measurements being considerably greater, and by its longer snout and mandible.

*Coloration.*—Above dark brown sometimes grizzled with grayish, becoming more grayish and yellowish about the face; below lighter, the sides of the belly chocolate-brown; limbs above like the back, distally becoming lighter brownish; naked parts blackish.

*Measurements.*—Skull: Occipito-nasal length 213 mm., greatest zygomatic breadth 135 mm., length of snout 74 mm., length of mandible 153 mm., width of nasals 29 mm., interorbital width 25 mm., mastoid breadth 128 mm., length of upper dental series 86 mm.

The fur-seal is undoubtedly a strictly resident species as is most of the littoral fauna. There is nothing in the physical conditions of the archipelago to cause migration. The climate is practically the same throughout the year, and the fishes which constitute the food of this seal are chiefly resident forms. The seals, moreover, appear to be confined to certain islands, that is, they return to breed annually upon the island upon which they were reared. It appears from the records of the sealers that since the beginning of sealing in the archipelago, this species has inhabited certain rookeries, and has remained upon these grounds through years of persecution, the rookeries ceasing to exist only when the bands were exterminated. Wenman Island for instance has always been a populous breeding ground and is at present the habitat of a considerable number of fur-seals.

This seal may now be considered rare in the archipelago. But two hundred skins were obtained by the crew of our schooner during six months' sealing. These were secured chiefly at Wenman, Narborough, and Albemarle islands, the greater number being taken at Wenman Island. None were seen on any of the other islands except Culpepper, where a single one was observed.

In habits the fur-seal is quite different from *Otaria*, being much more timid and wary, usually remaining hidden in caves and crevices between the rocks while ashore. This

difference in habits is perhaps due to its long persecution by sealers. The roughest parts of the coast are preferred, the sheltered coves resorted to so much by *Otaria* being ignored by *Arctocephalus*.

The seals are now so reduced in number and so scattered that no well-defined rookeries exist. On Wenman they were found in families scattered along the cliffs. Pups of various ages were found there in December. On Narborough they were confined to the roughest parts of the coast. This island was visited at various times during the months of January, March, and April. The rookeries were situated on rocky beaches, the seals being widely scattered and well concealed in holes and crevices. Pups were less common than on Wenman, but like those were of various ages, which led us to believe that no definite breeding season exists. On Albemarle the fur seals were found south of Iguana Cove on boulder-strewn beaches; they were found in similar situations at Point Christopher, which is north of the cove, and also in Bank Bay near the north end of the island. The rookeries at Point Christopher and Bank Bay are exceptional in their situation, being bathed by comparatively quiet water. The rookery on Tower Island is said to be confined to the southeast coast on a very rough part of the beach. Fur-seals have been reported from Abingdon Island, but none have been taken there recently.

*Arctocephalus* was formerly abundant in the Galapagos. In 1816 Fanning[1] reported from there a catch of eight thousand skins. As late as 1880 large catches were made, but the seals are now so diminished that one or two hundred are all that can be obtained in a season. However, they are apparently holding their own, for Captain William P. Noyes has for several consecutive years taken two hundred skins. The known records of fur-seal catches in the Galapagos account for approximately eighteen thousand skins, but these probably represent only a minor portion of the number actually taken.

[1] U. S. Fur Seal Investigations, pt. 3, 1899, p. 273.

MEASUREMENTS OF ARCTOCEPHALUS GALAPOGOENSIS.

| Age and sex | Locality | Total length | Tail vertebræ | Snout to shoulder | Snout to ear | Snout to eye | Ear | Width at shoulders | Width at ears | Interorbital width | Length of vibrissæ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ad. ♂ | Wenman Island | 1675 | 93 | 725 | 187 | 106 | 50 | 500 | 168 | 88 | 158 |
| " " | " " | 1475 | ... | 712 | 200 | 93 | 50 | 475 | 188 | 93 | 81 |
| " ♀ | " " | 925 | ... | 400 | 131 | 56 | 50 | 306 | 138 | 75 | 93 |
| " ♂ | Bank Bay, Albemarle Is. | 1750 | 112 | 825 | 200 | 93 | .. | ... | 212 | 88 | 75 |
| " " | " " " " | 1282 | ... | 632 | 168 | 93 | .. | ... | 175 | 75 | ... |
| " " | " " " " | 1675 | ... | 838 | 206 | 81 | .. | ... | 225 | 81 | 100 |
| " ♀ | " " " " | 1125 | ... | 490 | 156 | 68 | .. | .. | 144 | 68 | 125 |

Most of the skulls collected are those of immature animals, but there are in the collection three adult skulls, the measurements of which are given below. The adult skulls are markedly different from the immature ones, the greatest differences being the much narrower interorbitals, the greater development of the mastoid processes, and the presence of occipital and parietal crests.

MEASUREMENTS OF THE SKULLS.

| L. S. Jr. U. Zool. Coll. No. | Age and sex | Locality | Occipito-nasal length | Greatest zygomatic breadth | Length of mandible | Snout from lachrymal | Width of nasals | Interorbital width | Mastoid breadth | Length of upper dental row |
|---|---|---|---|---|---|---|---|---|---|---|
| 2480 | ad. ♂ | Wenman Island | 213 | 135 | 153 | 74 | 29 | 25 | 128 | 86 |
| 2481 | " " | " " | 203 | 124 | 135 | 63 | 22 | 28 | 107 | 80 |
| 2482 | " ♀ | " " | 200 | 120 | 129 | 58 | 22 | 27 | 102 | 75 |

No. 2480, old adult; sutures largely obsolete; occipital and parietal crests high.

No. 2481, nearly adult; occipital crests low; sutures distinct.

No. 2482, same as no. 2481 in age.

## Family VESPERTILIONIDÆ.

### Lasiurus *Gray*.

*Lasiurus* Gray, Zool. Misc. no. 1, 1831, p. 38.

*Range*.—Whole of the Nearctic, Neotropical, and Hawaiian Islands. Galapagos Archipelago (one peculiar species).

### Lasiurus brachyotis *(Allen).*

*Atalapha brachyotis* Allen, Bull. Am. Mus. Nat. Hist. v. 4, 1892, p. 47.

*Range.*—Chatham Island (Baur). Bats have also been seen on South Albemarle (Baur), and on Indefatigable (Habel).

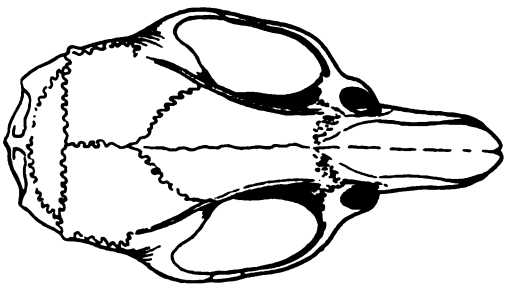
This species is said to be very close to *L. varia* of Chili, from which it differs chiefly in the smaller ears.

It was not observed by us.

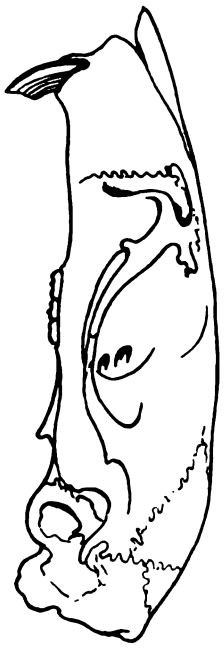
## EXPLANATION OF PLATE XXIII.

Figs. 1, 1a. *Oryzomys hatti* (2:1).
Figs. 2, 2a. *Nesoryzomys narboroughi*, type (2:1).

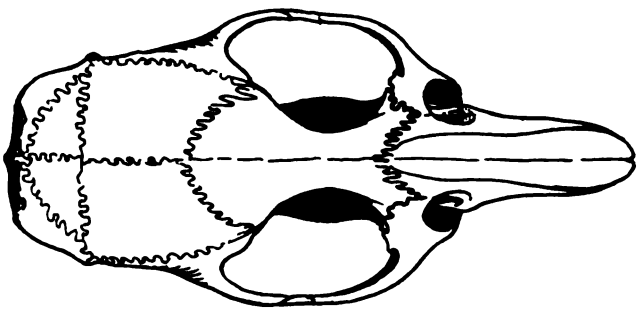
1a



1



2a



2

PHOTO LITH. BRITTON & REY, S.F.

PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

ZOOLOGY VOL. III, No. 8

# Notes on Fishes from the Gulf of California, with the Description of a New Genus and Species

BY

CLOUDSLEY RUTTER

WITH ONE PLATE

*Issued August 17, 1904*

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1904

# NOTES ON FISHES FROM THE GULF OF CALIFORNIA,

## WITH THE DESCRIPTION OF A NEW GENUS AND SPECIES.

BY CLOUDSLEY RUTTER.

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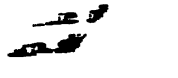
PLATE XXIV.

THE fishes here noted were collected incidentally during an expedition to the Gulf of California for the purpose of obtaining other material. In addition to the species listed below, one other unrecognizable species was found in the collection. It is a goby, apparently related to *Starksia*, but as it is less than an inch long and not in good condition, it is not possible to determine whether it ever possessed scales, and therefore it cannot be listed. The finding of one new genus, and probably two, during an hour's tide-pool collecting on one island, indicates a profitable field for further exploration.

1. **Ictalurus pricei** *(Rutter).*—The dermal villi which were supposed to distinguish this species and the genus *Villarius*, under which it was originally described, have been found in other species and genera of catfishes, notably in those from salt-water. This species is therefore referred to the genus *Ictalurus*. A single specimen was taken by Eisen and Vaslit at Tepic, Mexico, in November, 1894, along with *Heros beani*.

2. **Fierasfer arenicola** *Jordan & Gilbert.*—A single specimen four inches long, from San José Island, Gulf of California; collected by W. E. Bryant, in 1892.

3. **Heros beani** *Jordan.*—Several specimens of this species were collected by Eisen and Vaslit at Tepic, Mexico, in November, 1894.



minute teeth behind the front teeth of lower jaw, which are bent outward; lateral teeth of lower jaw curved backward. Minute teeth on vomer; a single row of teeth on palatines, about like those of sides of jaws. No large posterior canines. Gill-membranes united, free from isthmus. Dorsal high and long, beginning at occiput, anterior spines 2.6 in body, broadly arching to soft portion of fin, the rays of which are 1.8 in head; the two portions separated by a slight notch. Anal similar to soft dorsal, but longer. Both dorsal and anal joined to caudal. Caudal rounded. Pectoral broad, equal to head behind eye. Ventrals of one spine and two simple jointed rays, five in body. No lateral line.

Color uniform slaty black, fading posteriorly; caudal colorless. A few scattered small bluish spots on sides posterior to spinous dorsal. Alternate interspinal spaces of dorsal black. Dorsal spines and anterior rays of anal bluish. Younger specimens, 1.2 inches long, with about eight lighter spaces on sides.

Seven specimens from San José Island, Gulf of California; the largest 1.8 inches long; collected by W. E. Bryant, in 1892.

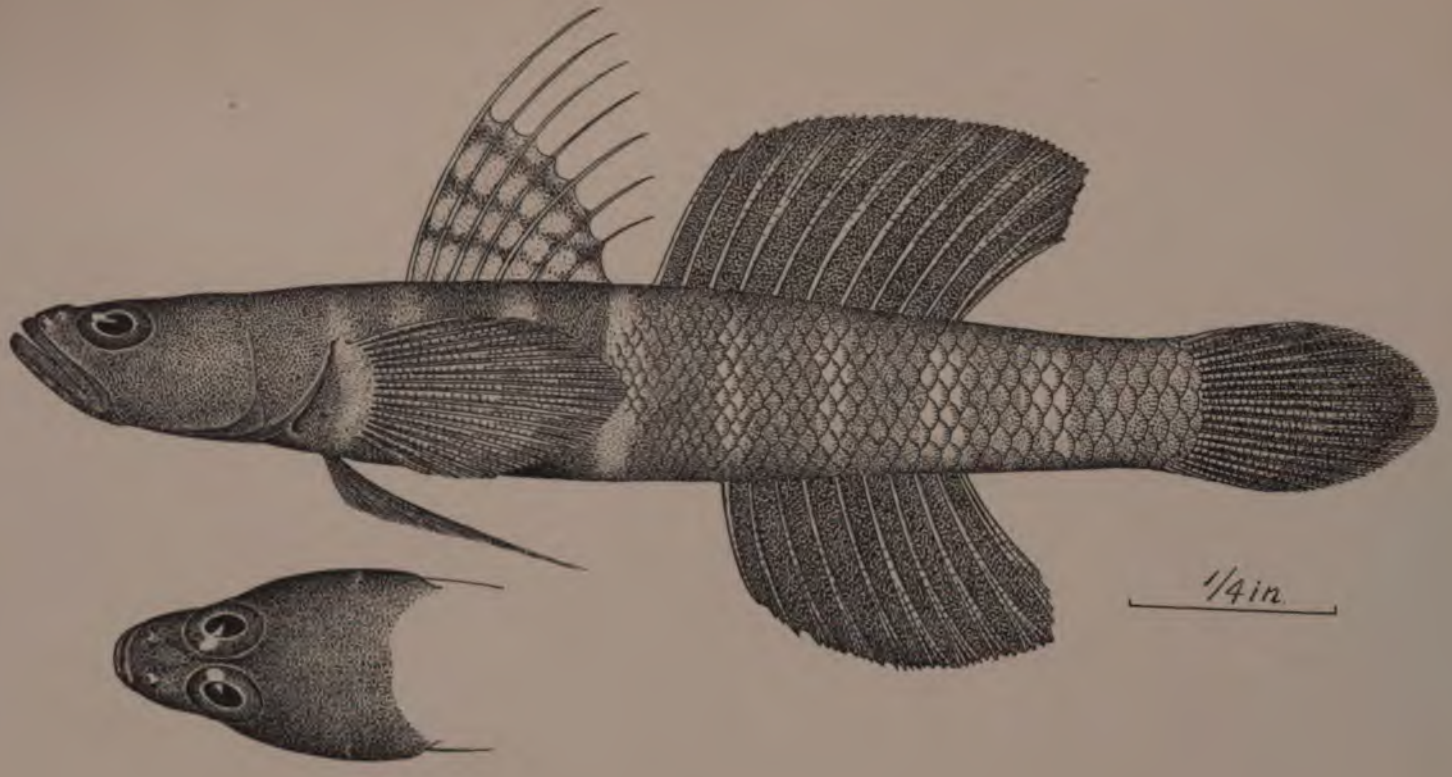
7. **Hypsoblennius gentilis** *(Girard).*—Four specimens, the largest 3 inches long. Smaller specimens, 1.3 inches long, are without color markings. Uniform dusky anteriorly, fading to colorless posteriorly. Collected at San José Island, Gulf of California, by W. E. Bryant, in 1892.

8. **Gobius dalli** *Gilbert.*—Six specimens, the largest 1.4 inches long, from San José Island, Gulf of California; collected by W. E. Bryant, April, 1892.

9. **Citharichthys gilberti** *Jenkins & Evermann.*—Two specimens from San José del Cabo, Lower California, the largest 5 inches long; collected by Gustav Eisen.

## EXPLANATION OF PLATE XXIV.

For "*Dichomma semisquamatum*" read *Pycnomma semisquamatum*.




DICHOMMA SEMISQUAMATUM, SP. NOV.

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# Notes on Fishes from the Pacific Coast of North America

BY

CHARLES H. GILBERT

WITH FIVE PLATES

*Issued August 20, 1904*

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1904

# NOTES ON FISHES FROM THE PACIFIC COAST OF NORTH AMERICA.

BY CHARLES H. GILBERT.

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PLATES XXV-XXIX.

## 1. **Netuma mazatlana** new species.

PLATE XXV.

*Arius platypogon* Jordan & Gilbert, Bull. U. S. Nat. Mus. v. 2, 1882, p. 44; Mazatlan (not *Arius platypogon* Günther).

*Netuma platypogon* Jordan, Proc. Calif. Acad. Sci. 2d ser. v. 5, 1895, p. 400; Mazatlan. Jordan & Evermann, Fish. N. and M. Amer. pt. 3, 1898, p. 2767; Mazatlan.

*Type:* ♀; 294 mm. long; no. 7138 Leland Stanford Junior University Zoological Collections; Mazatlan, Mexico. Jordan Collection, 1895.

This species is abundant at Mazatlan, Mexico, and in the Gulf of California, and has been erroneously identified with *Netuma platypogon* from Panama and Central America. It differs from *platypogon* in the smoother head, which bears finer granules and is more frequently covered with thickened integument, in the much narrower fontanelle groove, in the narrow occipital process and predorsal plate, the smaller axillary pore, the smaller adipose fin, and the absence of either black coloration or a ridge of thickened integument on the inner faces of the ventral fins.

In the type the head is contained 3⅘ times in length to base of caudal; width of head 5½; depth of head 6. In male specimens the head is larger in all its dimensions than in females, as is the case also in *N. platypogon*. The eye is contained 5⅘ times in head, measured around the lateral contour. The interorbital width equals half head, and slightly exceeds width of mouth. Snout 2⅘ in head. The maxillary barbel reaches to end of basal fifth of pectoral spine. Outer mental barbel 1½, inner, 2$\frac{1}{10}$ in head. Width of occipital plate 1⅓ in its length (about 1½ in *platypogon*).

The fontanelle groove is very narrow, of nearly uniform width throughout, ending abruptly at a point ⅓ diameter of eye behind posterior edge of orbit. Its greatest width equals ¼ diameter of pupil. Axillary pore a very small slit, its length ⅓ diameter of pupil. Oblique height of adipose fin greater than the length of its base, which is contained 2¼ times in base of dorsal fin (not including rudimentary spine). Although the type is a female, the ventrals do not nearly reach front of anal. In another female of equal size, the ventrals overlap front of anal. It is therefore questionable whether differences in length of this fin depend upon sex. In none of our specimens is there present the thickened fold of integument on the inner face of the ventral fins characteristic of females of *platypogon*. The paired fins are more or less dusky on their inner face, but have no jet-black area on basal portion.

The type specimen has 18 anal rays, including rudimentary rays.

The palatine patches of teeth vary considerably in size, and are often not parallel along their inner edges—a variation found also in *platypogon*.

## 2. Nemichthys avocetta *Jordan & Gilbert*.

### The Pacific Snipe-eel.

A third specimen of the Pacific Snipe-eel was taken during the summer of 1898, off Waldren Island in the southern part of the Gulf of Georgia, and was presented to the Museum of Stanford University through the kindness of the collector, Mr. W. H. Thacker of Friday Harbor, Washington, and of Mr. Ashdown H. Greene of Victoria, British Columbia.

It is worthy of note that the specimen was captured while "swimming on the surface of the water like a snake." In this connection we recall that the type of *N. avocetta*, taken in the harbor of Port Gamble, Washington, in 1880, was said to be "extremely active in the water." The majority of the known specimens of Snipe-eels have been taken during trawling operations in the Atlantic, at reputed depths of from 216 to 2369 fathoms (see Goode & Bean, Oceanic Ichthyology, p. 152). Some or all of these, however, may have entered the net on its way to the surface, and have lived at more moderate depths than the figures would indicate. The alternative would be, that these forms can accommodate themselves to life at the surface or at any depths in the oceanic basins. We are without information as to the conditions under which Richardson's type of *N. scolopaceus* was captured "in the South Atlantic." Lowe's

specimen from Madeira was brought in by fishermen, and was probably taken at or near the surface. This seems also probable for the specimen noted by Goode and Bean, which was brought into Gloucester, Massachusetts, by a George's Bank fisherman.

The specimen of Pacific Snipe-eel here recorded is in perfect condition, with fins and jaws uninjured and the filamentous tail intact. The fin membranes are flexible, and permit thus a more detailed examination of the structure of the dorsal and anal fins than is usually possible. From this it becomes apparent that the structure of the dorsal fin has been frequently misunderstood. In his original description of the species Richardson states: "The back is furnished with a numerous series of short subulate acute rays, each having a short membrane in its axilla, and being destitute of joints, but shrivelling as they dry, and without pungency." He presents also an enlarged detailed drawing, showing the dorsal fin to consist of short strong disconnected spines, much as in *Notacanthus*, but more closely spaced. A similar structure is indicated by Jordan and Gilbert in their account of the Nemichthyidæ (Fishes of North America, p. 366), "Dorsal beginning close behind occiput, its anterior rays soft, succeeded by a long series of very low spines, which are slightly connected by membrane . . . on the tail the spines again give place to soft rays." Again, in a note on a specimen of *N. avocetta*, Dr. Jordan observes, "A generic character of *Nemichthys* not heretofore noticed is the division of the dorsal rays into two sorts, near the middle of the body, the anterior series being much longer than the others, and all being undivided or spine-like" (Proc. Calif. Acad. Sci. 2d ser. v. 6, p. 206). The figure which accompanies this statement shows an abrupt transition from one kind of ray to the other, the anterior rays being long and slender, similar to the anal rays, while those on the posterior half of the body are short disconnected spines. Lowe figures a somewhat similar condition in his Madeira specimen, where the middle third of the fin consists of short spinous rays, which increase abruptly toward the head and the tail. On the other hand Goode

and Bean, with other writers, describe and figure the dorsal rays as uniform in character throughout, decreasing gradually in length from the middle of the body toward either end.

Examination of the recently acquired specimen shows that the dorsal fin is composed throughout of long slender rays, each of which becomes very delicate and thread-like distally. The basal part of each is comparatively strong and stiff, and passes abruptly into the delicate terminal portion. This division of each ray into two portions is most strikingly shown along the posterior part of the back, between the middle point and the slender part of the tail. It thus often happens that when the dorsal membrane is dried down, or unduly hardened by the preservative, the distal portions of the rays in this region become detached from the basal spine-like portions, while this does not occur anteriorly, or along the slender part of the tail. The specimen figured by Dr. Jordan, above referred to, has been returned to me for re-examination, through the great kindness of Mr. John Fannin, Curator of the Provincial Museum, Victoria, British Columbia. The basal parts of the posterior rays are for the most part detached from the filamentous ends, but the latter can still be detected, imbedded in the hardened membrane, and an occasional ray in the "spinous" area has the terminal portion still connected with the base. A similar specimen from the Atlantic shows the same structure. It is thus apparent that in the structure of the dorsal fin *Nemichthys* does not differ essentially from related genera.

In our specimen from the Gulf of Georgia, the jaws are widely recurved at tip, the upper jaw being two millimeters longer than the lower. The teeth are minute, close-set, equal, with retrorse points. They entirely cover the opposed surfaces and the sides of both jaws, and are regularly arranged in quincunx order. The toothed area on the maxillary extends to opposite the posterior edge of the pupil.

The gill opening begins opposite the middle of the base of the pectoral fin, and extends obliquely downward and forward, the anterior (lower) ends of the two openings

being separated by a distance slightly less than the width of the interorbital space.

The vent is nearer the base than the tip of the pectoral fins, the anal fin beginning immediately behind it. In this respect our specimen agrees closely with the type of *N. avocetta*, and differs from the specimen reported on by Dr. Jordan (Proc. Calif. Acad. Sci. 2d ser. v. 6, 1896, p. 205, pl. XXI), in which the vent is under the extreme tip of the pectorals. In the figure above cited, the vent is made to appear still more remote from the head; but in this the artist was in error, as a re-examination of the specimen has shown. The variation in the position of the vent, shown by the three known specimens of the species, seems not excessive when compared with similar variations in other species of eels.

The type of *N. avocetta* is erroneously described as having no lateral line. A distinct line is present in the specimen here described, and is provided with very minute pores in three series, as figured by Goode and Bean for Atlantic specimens.

The following table of measurements will serve for comparison:

| | |
|---|---|
| Total length | 710 mm. |
| Greatest depth of body | 8½ mm. |
| Least depth of "neck" | 4 mm. |
| Length of head | 59 mm. |
| Greatest depth of head | 8 mm. |
| Length of snout | 45 mm. |
| Diameter of eye | 5 mm. |
| Least interorbital width | 2¼ mm. |
| Distance from vent to gill slit | 6 mm. |
| Length of pectoral | 10 mm. |
| Height of anal | 10 mm. |

*Nemichthys avocetta* is very closely related to *N. scolopaceus* from the Atlantic and may prove indistinguishable from it. I have been unable to verify the slight differences in proportions of parts, said to distinguish the two forms. The eye may average a little larger in Pacific specimens. I do not venture to unite the two in advance of a detailed comparison of satisfactory material from the Atlantic and the Pacific.

## 3. Schedophilus heathii new species.

PLATE XXVI.

*Type:* 84 mm. long; Pacific Grove, California, July 18, 1896; collector Harold Heath.

The type is a young individual, found in company with a jelly-fish, beneath which it was captured.

From *S. lockingtoni* it differs widely in all proportions of head and body, and in the striated scales; from *S. maculatus* (= *S. marmoratus* Kner) it differs in the much more numerous fin rays and in the plain coloration; from *S. medusophagus* in the larger scales, plain coloration, the absence of spines on the opercular bones, the more posterior dorsal fin, and in other respects.

D. 9+35; A. 28; P. 21; V. I, 5. Scales in course of lateral line 116 or 118.

Length of head $2\frac{9}{10}$ in length to base of caudal; greatest depth $2\frac{1}{2}$; least depth (at caudal peduncle) $\frac{1}{3}$ the greatest depth. The eye is large, with prominent supraorbital ridge, its diameter contained $3\frac{2}{3}$ times in length of head. The lower jaw is shorter than the upper, included within the premaxillaries both laterally and at the symphysis. The mouth is moderately oblique, the premaxillaries anteriorly on the level with lower margin of orbit, the maxillary slightly decurved toward its extremity, wholly concealed beneath the preorbital, the tip reaching the vertical from the posterior margin of the pupil. The teeth are perfectly straight, very sharp and slender, in a single series in each jaw; the vomer and palatines are toothless.

The snout is blunt and heavy, the interorbital region broad, flattened transversely. From its posterior line rises a high occipital crest, which is continuous with the sharply compressed basal area of the dorsal fin. None of the bones of the head bear conspicuous spines. The preopercle and opercle are marked with faint striæ, which end at the margins of these bones in scarcely distinguishable spinous points.

The bases of the dorsal and anal fins are very closely compressed; the basal bones of the fins readily visible. The origin of the dorsal fin falls vertically over a point midway between insertion of ventrals and origin of anal fin. It is there wholly behind the head, and over the middle of the length of the pectoral fin. The anterior rays are not sharply differentiated from the remainder of the fin. The first 9 are short, with few articulations, and increase in length very slowly. Behind these, the rays grow rapidly longer, are slenderer, more closely set, and have more numerous articulations. The origin of the anal fin is under the thirteenth or fourteenth ray of the dorsal, the 2 fins terminating posteriorly at the same vertical. The anterior anal rays seem not at all differentiated from the others. The ventrals are inserted under the middle of the pectoral base, their tips reaching slightly more than half way to origin of anal fin. The ventral spine is very slender and flexible,

but is without articulations. The pectorals are short and broadly rounded; 2 upper rays and 5 lower rays are simple, the others branched. The caudal peduncle is widened posteriorly by the numerous procurrent rays of the caudal fin. The caudal is rounded posteriorly, its length equaling the distance from middle of pectoral base to front of orbit.

The scales are small, with strong concentric striæ, only 2 or 3 of which are visible in scales on sides of body; more than this number on the larger scales of the head. The bases of the vertical fins are scaly, the paired fins naked. The opercles, the cheeks, and the top of head as far forward as the posterior line of the interorbital space are completely invested with comparatively large scales, the mandible, snout, and interorbital area alone naked. The lateral line is strongly arched anteriorly, its least distance from dorsal outline ⅓ its distance from upper axil of pectorals.

The color is uniform brownish gray or olive, the top of the head and the vertical fins darker.

MEASUREMENTS IN HUNDREDTHS OF LENGTH WITHOUT CAUDAL.

| | |
|---|---|
| Total length 84 mm. | |
| Length to base of caudal 66 mm. | =100 |
| Length of head | 34 |
| Length of snout | 8 |
| Diameter of eye | 9½ |
| Interorbital width (over middle of eye) | 12½ |
| Length of maxillary | 12½ |
| Greatest depth (over ventral fins) | 38 |
| Least depth (caudal peduncle) | 12½ |
| Depth of head (at occiput) | 29 |
| Distance from tip of snout to front of dorsal | 51 |
| Distance from tip of snout to insertion of ventrals | 37 |
| Distance from tip of snout to origin of anal | 60 |
| Length of dorsal base | 46 |
| Length of anal base | 30 |
| Longest dorsal ray | 16 |
| Longest anal ray | 15 |
| Longest pectoral ray | 18 |
| Longest ventral ray | 13 |
| Longest caudal ray | 30 |

The genus *Icichthys* is said to differ from *Schedophilus* in the larger size of the scales and in the lack of any notable compression at the bases of the dorsal and anal fins. The species here described agrees with *Icichthys* in the size of the scales, and with *Schedophilus* in the compression of the bases of the fins. It is not probable that *Icichthys* can be retained as a valid genus.

I take pleasure in associating the species with the name of its discoverer, my friend and colleague, Dr. Harold Heath.

## 4. Xeneretmus infraspinatus new species.

PLATE XXVII.

*Type:* 99 mm. long, collected by the U. S. F. C. Steamer Albatross, at Station 3673, off Cape Flattery, Washington, May 14, 1897, at a depth of 77 fathoms.

Head 4⅓ in length; depth 9¼, slightly exceeding the distance from tip of snout to middle of eye. Dorsal VI-6; anal 7; ventrals 1, 2; pectorals 15, the lower 5 rays exserted. Lateral line 38. Plates in upper lateral series 39, in dorsal series 37.

The body is much more robust than in *X. pentacanthus*, being both wider and deeper. The width of the head equals the distance from tip of snout to hinder fifth of orbit. In *X. pentacanthus* of the same size, the depth of the body equals the distance from the tip of the snout to the front of the pupil; the width of the head equals the distance from the tip of the snout to the hinder edge of the pupil.

Eye ⅓ the length of the head, slightly longer than the snout. Snout narrower than in *X. alascanus*, its greatest width very slightly exceeding its length. The rostral plate has 3 short spines on its upper margin directed upward and backward, and 1 spine at each outer angle directed outward and backward. The nasal spines are strong. The supraocular ridges are strong, bounding the narrow deeply channeled interorbital space, the least width of which equals the diameter of the pupil. The preocular portion of the ridge bears small diverging striæ, which end along the edge of the ridge in a series of minute spines. There are a strong postocular spine and 2 spines on each of the bluntly elevated occipital ridges. A weak postocular pit is present, and a stronger nuchal pit, both of them much less marked than in *X. alascanus*. There is the usual series of spinelets on the eyeball. The subocular ridge is not prominent, bearing a minute spine anteriorly and 1 or 2 posteriorly. Preopercular and opercular spines as usual in the genus. The cheeks below the ridge are covered with 2 or 3 heavy gibbous plates, coalesced and immovable, the centers elevated and bearing minute backwardly-directed spines. Lower margin of preorbital with 8 or 9 strong spines, the anterior 3 directed forward, the others downward, or downward and backward. These spines are still undeveloped in the cotype, 49 mm. long.

There are 2 pairs of barbels on the under side of the mandible near the symphysis, arising from margins of pores. Two unequal barbels occur near the tip of each maxilla. The gill membranes are broadly joined to the isthmus—their posterior margin with a narrow but well-defined free fold.

The plates on the body are essentially as in *pentacanthus* and *alascanus*, the spines not so sharp as in the former, but better developed than in the latter. The spines of the lower lateral series do not diminish in size posteriorly, while in *alascanus* they become almost or quite obsolete on the caudal peduncle. There is a single pair of plates in front of the base of the ventrals as in *alascanus*, the rest of the median series being unpaired. All of the breastplates are heavy, marked with fine striations, without spines except in the very young cotype. The gular and branchial membranes are provided with plates.

The pectorals are long, reaching to below the middle of the spinous dorsal, the lower rays slender, but produced and exserted. The ventrals are long in the type specimen, reaching half way to the origin of the anal fin (from ½ to ¾ this distance in *alascanus* and *pentacanthus*).

The color is light olivaceous, with faint traces of lighter bars; under parts white. The ventrals are white, the other fins faintly dusky, not with conspicuous black areas as in *pentacanthus*.

A second specimen, 49 mm. long, was taken at the same locality. The fin rays are: Dorsal VI–6; anal 7; pectoral 15.

The species is most nearly related to *X. alascanus*, but is in some respects intermediate between that species and *X. pentacanthus*. From *pentacanthus* it differs in the deeper wider interorbital groove, the higher and stronger ridges and spines on the head, the deeper occipital depression, the heavy coalesced plates on the cheek below the suborbital ridge, the presence of but one pair of pre-ventral plates (the rest of the median series being unpaired), and the greater width of the pre-ventral area, the plates of which are thick, very finely granular, and without spines. From *alascanus* it differs in the narrower head and body, the weaker development of spines and ridges on the sides of the head, and the longer ventral fins. It differs conspicuously also in the strong spines of the lower lateral plates, those in *alascanus* being weak or obsolescent, especially on the caudal peduncle.

From both species it differs in the more posterior anal opening, which is on the third instead of the second plate behind the base of the ventral fins. It has also a narrow but easily appreciable free fold along the posterior margin of the gill membranes near the median line; the lower margin of the preorbital is spinous.

### 5. Clevelandia ios *Jordan & Gilbert.*

*Gobiosoma ios* Jordan & Gilbert, Proc. U. S. Nat. Mus. v. 5, 1882, p. 437; Saanich Arm, Vancouver Island. Jordan & Gilbert, Synop. Fish. N. A. 1883, p. 948. Jordan & Eigenmann, Proc. U. S. Nat. Mus. v. 9, 1886, pp. 507, 509, 516, 517.

*Clevelandia ios* Jordan & Starks, Proc. Calif. Acad. Sci. 2d ser. v. 5, 1895, p. 839, pl. c. Jordan & Evermann, Fish. N. and M. Amer. pt. 3, 1898, p. 2254.

*Clevelandia longipinnis* Eigenmann & Eigenmann, Proc. Calif. Acad. Sci. 2d ser. v. 1, 1888, p. 73; San Francisco (not *Gobiosoma longipinne* Steindachner). Eigenmann & Eigenmann, Proc. Calif. Acad. Sci. 2d ser. v. 3, 1890, p. 10. C. H. Eigenmann, Amer. Nat. Oct. 1889, p. 916. C. H. Eigenmann, Zoe, May, 1890, pp. 65–68, pl. II, figs. 1–4r. Eigenmann & Eigenmann, Ann. N. Y. Acad. Sci. v. 6, 1892, p. 354. C. H. Eigenmann, Proc. U. S. Nat. Mus. v. 15, 1892, p. 159, pl. XIV, figs. 5 and 5r.

*Clevelandia rosæ* Jordan & Evermann, Proc. Calif. Acad. Sci., 2d ser. v. 6, 1896, p. 229 (based on *C. longipinnis* Eigenmann & Eigenmann; San Francisco, written San Diego through error). Jordan & Evermann, Fish. N. and M. Amer. pt. 3, 1898, p. 2255.

*Clevelandia ios* was originally described from a partially digested specimen procured on the eastern shore of Vancouver Island. The imperfect condition of its integument gave rise to the erroneous statement that the species was scaleless; and the mutilation of the anal permitted but twelve rays to be determined in that fin. The ascription of six spines to the dorsal fin was doubtless an error.

No additional specimens were reported until 1895, when two individuals were dredged by Mr. E. C. Starks in the vicinity of Seattle, Washington. The elongate form, the many-rayed fins, and the produced maxillary permitted no doubt of the identity of these with "*Gobiosoma ios*," which could now be assigned its proper place in the system.

In the meantime Eigenmann and Eigenmann had described as *Clevelandia longipinnis* (Steindachner), a specimen from San Francisco, in the Museum of Comparative Zoology at Cambridge. The same species was taken by these authors subsequently in abundance at San Diego. Well founded doubts then arose as to the propriety of identifying the species with *longipinnis*, and the specific name *rosæ* was proposed by Jordan and Evermann. This was based on the San Francisco specimen described by Eigenmann and Eigenmann, which was erroneously ascribed by Jordan and Evermann to San Diego.

In the "Fishes of North and Middle America," Jordan and Evermann recognize two species of *Clevelandia; C. ios*, confined as far as known to Puget Sound, and *C. rosæ*, ranging from San Francisco to San Diego. *C. rosæ* is said to be distinguished principally by having four instead

of five dorsal spines, and by certain minor differences in the proportions of head and body, the size of the eye, and the number of fin rays.

In the ichthyological collections of Stanford University, there are now some seventy-five young specimens of a *Clevelandia* collected at the mouth of Butano Creek, near Pescadero, San Mateo County, California, by Mr. James M. Hyde. They are within the range therefore of *Clevelandia rosæ* and near the type locality of the species. These specimens have been compared with typical *ios* from Puget Sound (the Seattle specimens already referred to) and with a specimen of *rosæ* from San Diego, kindly furnished for that purpose by Dr. Eigenmann. No doubt can remain that the two species are not distinguishable and must be united under the oldest name.

The type of *C. rosæ* is described as having four dorsal spines. From the following table it appears that five is the usual number, varying rarely to four. There are usually sixteen dorsal rays, varying rarely to seventeen, and fifteen anal rays, varying to sixteen. The statement by Jordan and Starks (see synonomy) that the Seattle specimens had fourteen anal rays is erroneous. In their accompanying illustration the number is correctly represented as sixteen.

TABLE OF FIN RAYS.

| LOCALITY | DORSAL | ANAL |
|---|---|---|
| Seattle..... | V-16 | 16 |
| | V-17 | 16 |
| San Diego..... | V-16 | 15 |
| Pescadero..... | IV-16 | 15 |
| | V-16 | 15 |
| | V-16 | 15 |
| | V-16 | 15 |
| | V-16 | 15 |
| | V-16 | 15 |
| | V-16 | 15 |
| | V-16 | 16 |
| | V-16 | 16 |
| | V-17 | 16 |

The following table of measurements shows that there are no differences in proportions between northern and southern specimens. The larger eye in the type of *C. rosæ* was almost certainly due to the state of preservation of the specimen.

In our Pescadero specimens the ground color is light grayish olive, the back and the upper half of the sides marked with dark specks, arranged in lines which interlace to form a regular coarse meshwork, which encloses polygonal spaces of the ground color. Where these lines cross the mid-dorsal line, they become locally intensified, and form a series of twelve or thirteen rather ill-defined dark spots. A dark spot is present opposite the base of the upper pectoral rays, a bar at base of caudal, and a number of faint transverse bars on the dorsal and caudal fins.

The genus *Clevelandia* is very closely related to *Evermannia* and *Ilypnus*—all forms with more or less reduced cycloid scales, with reduced spinous dorsal and elongate soft dorsal and anal, with large mouth and more or less

produced maxillary, and with fleshy appendages on the inner border of the shoulder girdle. *Clevelandia* and *Evermannia* have been described as lacking these appendages; but in *Evermannia* there is invariably a single conspicuous slender fleshy slip, precisely similar to the one present in *Ilypnus;* while in *Clevelandia* there is a low but sharp cutaneous fold or keel, which exhibits enlargements at two or three points along its course, there forming low papillæ. While this structure is low and inconspicuous, it does not differ essentially from that found in *Lepidogobius.* The characters relied upon to distinguish *Clevelandia*, *Ilypnus*, and *Evermannia* are not of high value, but the genera admit of definition and contain what are unquestionably natural assemblages of species.

TABLE OF MEASUREMENTS IN HUNDREDTHS OF LENGTH WITHOUT CAUDAL.

| | SEATTLE, WASH. | | PESCADERO | |
|---|---|---|---|---|
| Total length in mm | 50 | 49 | 38 | 35½ |
| Length to base of caudal in mm. | 41 | 41 | 31 | 29 |
| Length of head | 26 | 27 | 27 | 26 |
| Length of maxillary | 15 | 16 | 15½ | 14½ |
| Length of snout | 8 | 8 | 8 | 8 |
| Diameter of eye | 5 | 4½ | 5 | 5 |
| Interorbital width (bone) | 2 | 2 | 2 | 2 |
| Depth of body | 16 | 16 | 15½ | 16 |
| Depth of caudal peduncle | 7 | 7½ | 8 | 7 |
| Base of spinous dorsal | 9½ | 9 | 10½ | 9 |
| Distance between dorsals | 9½ | 9 | 8 | 8½ |
| Base of second dorsal | 33 | 32 | 33 | 32 |
| Base of anal | 29 | 27 | 30 | 27 |
| Length of pectoral | 19 | 18½ | 17 | 17 |
| Length of ventrals | 18 | 19½ | 19 | 18 |
| Length of caudal | 21 | 21 | 21 | 22 |

## 6. Rathbunella alleni new species.

PLATE XXVIII.

Differing from *R. hypoplecta*, the only previously known member of the genus, in its much deeper form, the ctenoid scales, the fewer unbranched dorsal rays, the presence of a naked strip before dorsal fin, and in the coloration.

*Type:* 166 mm. long; Monterey Bay, California; collector W. F. Allen.

Head 4⅓ to 4⅔ in length; depth 5 to 5⅔. Least depth of caudal peduncle 2⅔ in length of head. Dorsal 44 or 45; anal 33; ventrals 1, 5; pectorals 17. Br. 6. Pyloric cæca large, 4 in number.

The mouth is very oblique, larger than in *R. hypoplecta*, the maxillary extending beyond the vertical from the middle of the orbit, contained 2⅔ in the length of the head. In the front of the premaxillaries, the teeth are in a broad villiform band, with an outer series of moderate canines; laterally the band diminishes rapidly in width, the outer series of reduced canines alone reamining near angle of mouth. The mandibular band is wider than the premaxillary band, but likewise tapers to a single series laterally. The outer series is more or less enlarged, 1 or more larger canines sometimes present at the middle of each side of the jaw. Very broad bands of minute villiform teeth cover continuously the vomer and the adjacent portions of the palatines, the two separated only by narrow oblique lines. The transverse length of the vomerine patch slightly exceeds the length of the palatine patches, the width of the patches but slightly less than their respective lengths. Eye equal to length of snout, ⅓ length of head, the snout a trifle longer in the cotype. The interorbital width is narrow, ⅓ or ⅜ the diameter of the orbit. Gill membranes with 6 rays, broadly joined across the throat, forming a free fold, the width of which equals the diameter of the eye. Gill rakers short, almost tubercular, spinous, 13 in number. A short slit is present behind the last gill arch, which bears a double set of filaments. The pseudobranchiæ are well developed, but form a small patch. Parallel with the outer gill arch there is attached to the inner surface of the cheeks, a wide membranous fold, the free edge of which is produced into a series of short processes equaling in size the gill rakers of the outer arch, and alternating with them. They thus form an interlocking mechanism between the fold and the outer gill arch, and function in the same manner as the gill rakers of succeeding arches. Pores are developed on the head as in related species. The cheeks are covered with very fine scales, the rest of the head naked.

The posterior border of the orbit is midway between the tip of the snout and the origin of the dorsal fin. The first 5 dorsal rays are unbranched, and are distinctly articulated, with the possible exception of the first and second rays. The first anal ray is concealed in the membrane, unbranched and unarticulated; the succeeding anal rays are all branched and articulated. The longest dorsal ray is half as long as the head. The caudal is broadly rounded, a trifle shorter than the pectoral, ⅔ to ¾ the length of the head. The width of the pectoral base equals the length of the snout and half the eye. The ventrals are inserted in advance of the pectorals; the inner rays are the longest, and reach half way from the base of the fin to the vent.

The scales are small, evidently ctenoid, but minutely so. They are reduced in size and appear cycloid on the breast and belly, and in advance of the pectoral fin. There is a wide naked strip in front of the dorsal fin. The lateral line runs high and parallel with the back, containing 83 pores, and terminating at a distance from the base of the caudal equaling half the length of the head. The lateral line consists of a series of vertically elongate slits, which give the appearance of enlarged scales, but do not correspond with the scales in any way. In *Ronquilus jordani* the same structure has

been mistaken for enlarged scales, and the same was doubtless true in *Rathbunella hypoplecta*.

The back is dark brown, nearly uniform, the lower parts light olivaceous, marked with about 8 inverted V-shaped incursions of the brown of the upper parts. In the cotype a faint series of blotches along the lateral line alternate with the V-shaped marks below, and are connected with them by oblique lines. Dorsal fin with oblique dark and light crossbars (uniform brown in the cotype); the anal is black, the rays conspicuously white-tipped. The caudal is dusky, the ventrals and pectorals light brown or straw color.

Two specimens are known, taken on long lines, in Monterey Bay.

The species is named for its discoverer, Mr. W. F. Allen.

### 7. **Auchenopterus mexicanus** new species.

PLATE XXIX.

*Auchenopterus monophthalmus* Jordan, Proc. Calif. Acad. Sci. 2d ser. 1895, v. 5, p. 501; Mazatlan (not of Günther). Jordan and Evermann, Fish. N. and M. Amer. pt. 3, 1898, p. 2372 (the description drawn from La Paz specimens, one of which serves as the type of *A. mexicanus*).

*Type:* 47 mm. long; no. 6486 Leland Stanford Junior University Zoological Collections; La Paz, L. C.; collector C. H. Gilbert.

Specimens of an *Auchenopterus* from the coast of Mexico at Mazatlan and La Paz agree closely with *A. monophthalmus* in coloration and general appearance, but differ constantly in the following respects: The first dorsal fin is lower, with stiffer pungent spines; the notch between the dorsals is not so deep; there are fewer scales in the lateral line; the dorsal ocellus is larger, while numerous smaller ocelli (absent in *A. monophthalmus*) often occur more anteriorly along the dorsal fin; the body is deeper; the supraorbital and nuchal tentacles are larger and more finely divided.

In *A. monophthalmus* of equal size, the depth of body is two-ninths to one-fifth the length; the lateral line contains forty scales; the membrane between the third and fourth dorsal spines is usually notched to the base, rarely joining fourth spine slightly above its base.

Head 3¼ in length; depth 4. D. III, XXVI, 1; A. II, 19. Scales 2-35 or 36-11. No variation was found in fin and scale counts in five specimens.

Maxillary reaching a point behind vertical from orbit, half length of head in the type, which is a male; in females the maxillary is much shorter, not reaching beyond the eye, and is less dilated at its extremity. Orbital tentacle narrow at the stem-like base, the distal half divided into 4 to 6 fringe-like filaments, the entire length half the vertical diameter of the orbit. A pair of similar, slightly shorter nuchal tentacles. Anterior nostril in a short tube, the posterior margin produced into a slender filament. Jaws with small conical teeth, the outer series slightly enlarged. The premaxillary teeth are mesially in a wide band, which narrows laterally into a single series continuous with the outer series of the band. One or 2 pairs of the inner mesial teeth of the premaxillary band are enlarged and directed almost horizontally backward. The mandibular teeth are similar to those in the premaxillaries, but form a narrower band anteriorly, with a longer single row along the side of the mandible. A single row of teeth on the vomer, similar to the outer series in the jaws; no palatine teeth. The mandibular symphysis projects slightly beyond the premaxillaries.

The head is naked, the body covered with large smooth scales, which are reduced in size on the nape and the abdomen; fins naked.

The origin of the dorsal fin is vertically above the margin of the preopercle. The anterior dorsal lobe is low, the first 3 spines shorter than any succeeding spines except the fourth. The notch between the third and fourth spines is comparatively shallow, the membrane joining the front of the fourth spine at about the middle of its height. The front of the anal fin is about midway between tip of snout and base of caudal (somewhat variable in position in other specimens, in which it may be slightly nearer either to the tip of the snout or to the caudal).

Color in spirits, light brownish gray, the sides with 7 or 8 rather faint broad brown crossbars, which are continued on the dorsal fin. In the interspaces between the bars are scattered small white spots. A narrow dark bar at base of caudal. An irregular non-ocellated black blotch on the first 2 dorsal spines. An ocellated spot much larger than the eye on the basal portion of the twenty-first to twenty-fourth dorsal spines. A variable number of smaller ocellated spots in front of this, sometimes 1 for each dark crossbar. Anal fin with oblique dark and light bars of nearly equal width. In the females the lower side of the head and the preopercular margin are finely speckled with white and brown, and the paired fins are finely crossbarred. In males these regions are plain.

TABLE OF MEASUREMENTS IN HUNDREDTHS OF LENGTH WITHOUT CAUDAL.

| | ♂ | ♀ |
|---|---|---|
| Total length in mm | 47 | 42 |
| Length of head | 29 | 29 |
| Length of snout | 6 | 6 |
| Length of maxillary | 16 | 13 |
| Diameter of orbit | 6½ | 7 |
| Interorbital width | 3 | 2½ |
| Greatest depth | 25 | 24 |
| Depth of caudal peduncle | 8 | 9 |
| First dorsal spine | injured | 8 |
| Second dorsal spine | 7 | 9 |
| Third dorsal spine | 7 | 7 |
| Fourth dorsal spine | 7 | 8 |
| Longest dorsal spine | 9½ | 11 |
| First anal spine | 6½ | 7½ |
| Second anal spine | 9 | 10 |
| Longest anal ray | 15 | 15 |
| Caudal | 22 | 22 |
| Ventral | 17 | 17½ |
| Pectoral | 24 | 22½ |

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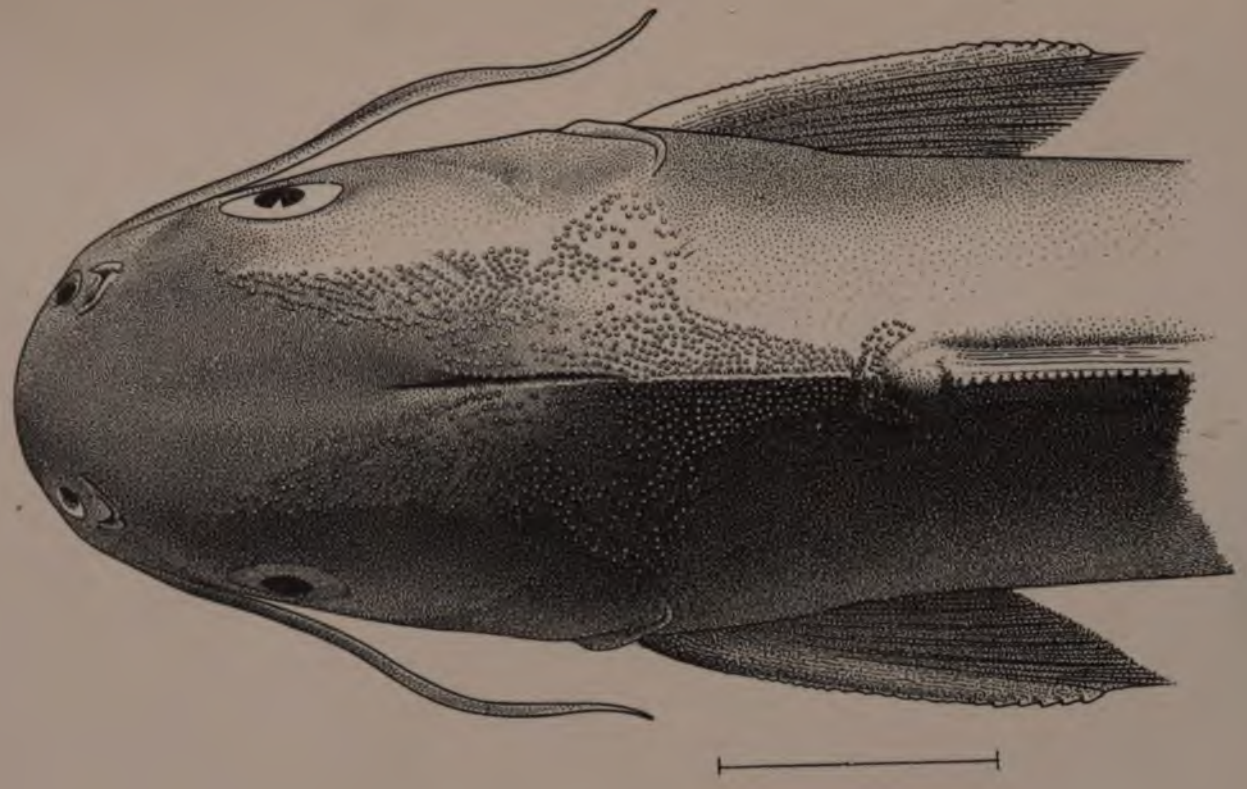

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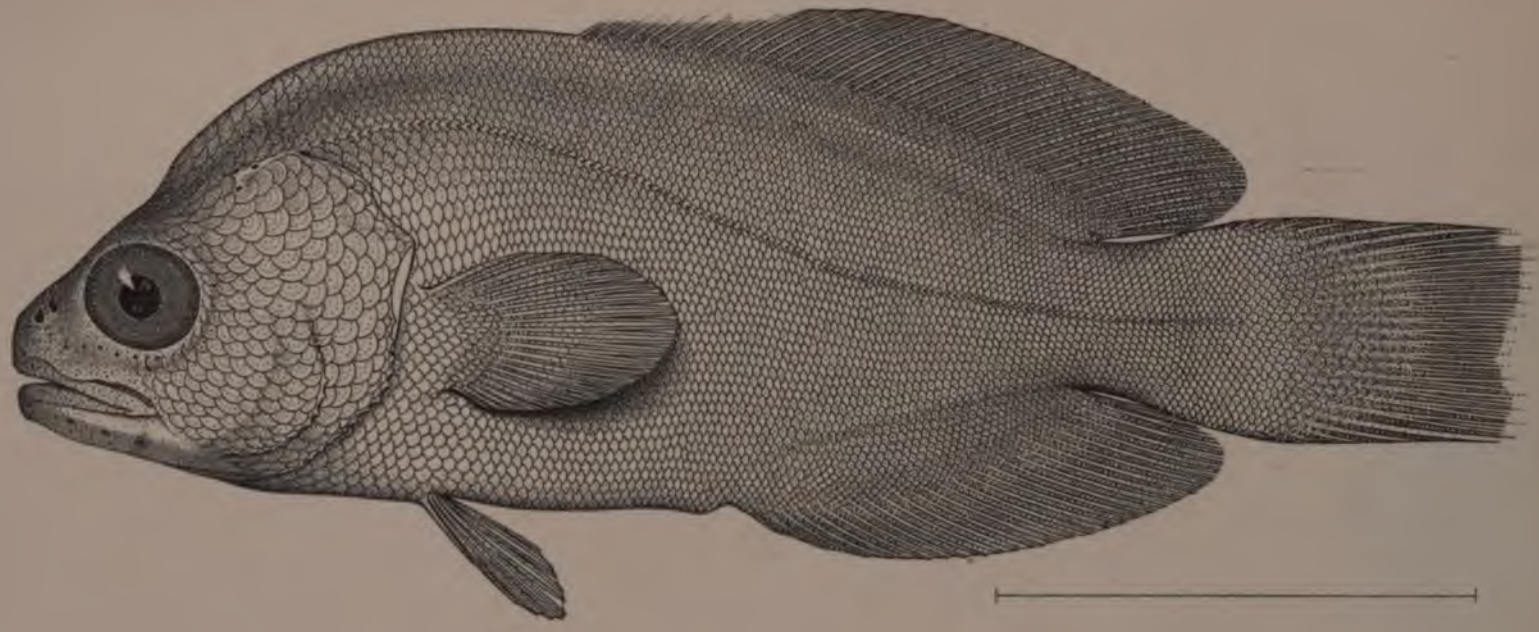

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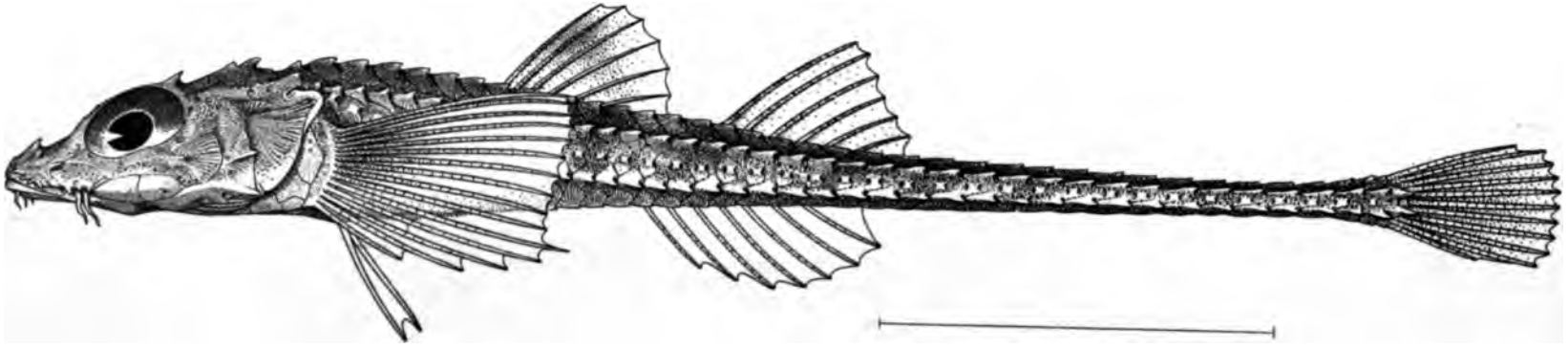

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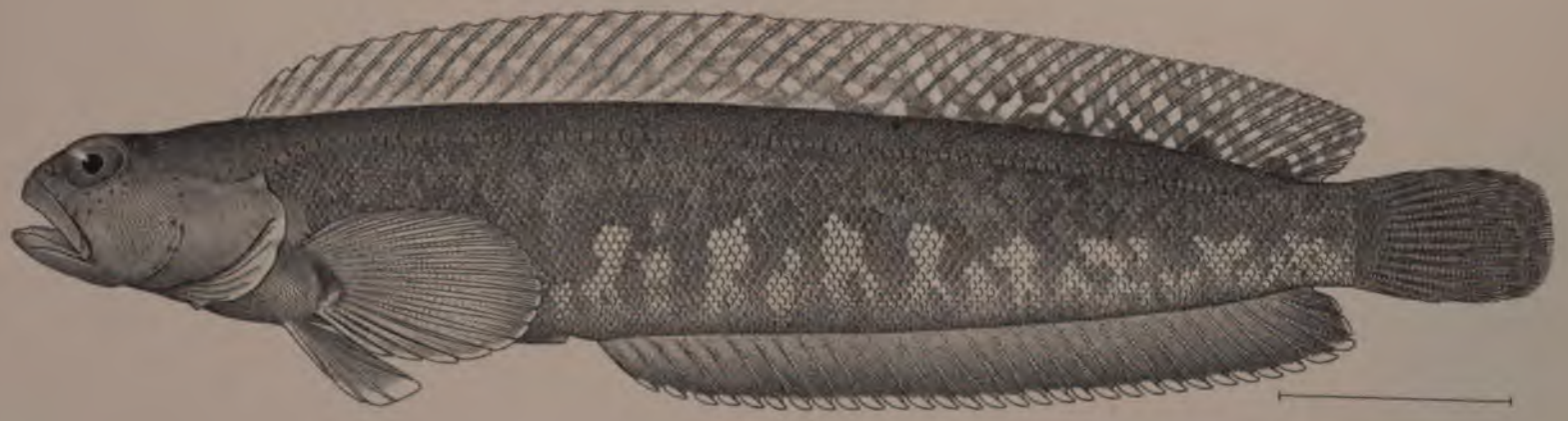
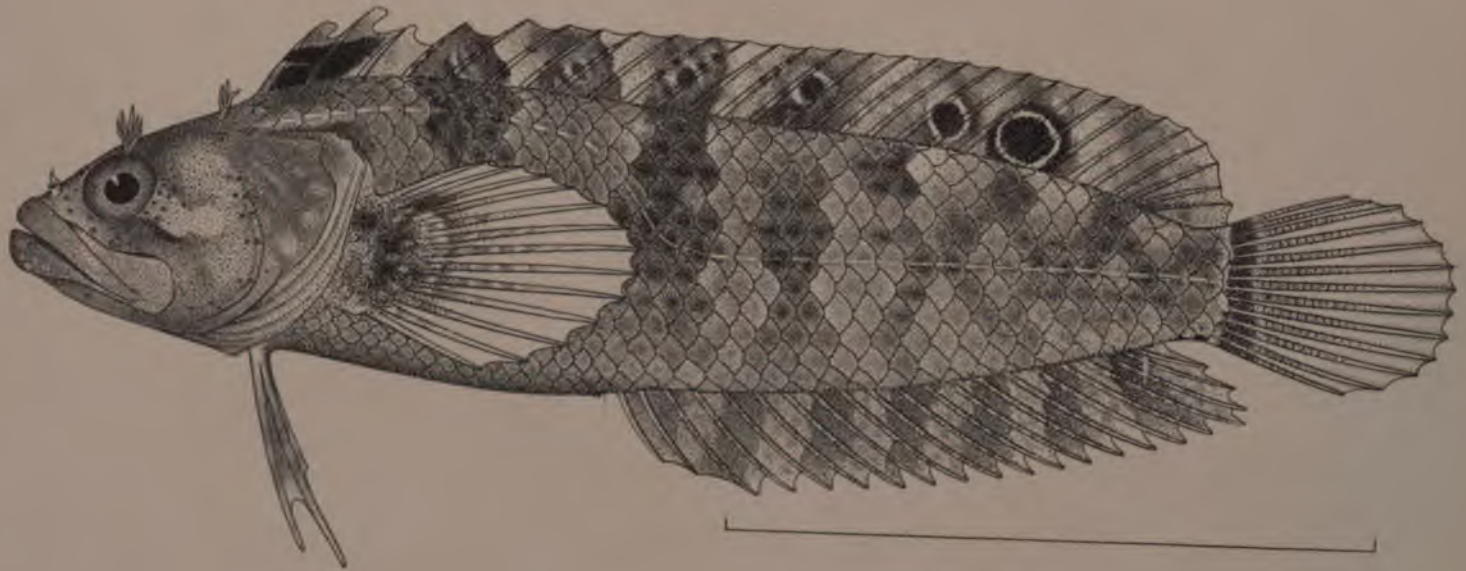


RATHBUNELLA ALLENI, SP NOV.



AUCHENOPTERUS MEXICANUS, SP. NOV.

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# The Hypopygium of the Dolichopodidæ

BY

ROBERT E. SNODGRASS

WITH FOUR PLATES

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# THE HYPOPYGIUM OF THE DOLICHOPODIDÆ.

BY ROBERT E. SNODGRASS.

PLATES XXX-XXXIII.

THE term *hypopygium* as used by the writer refers to the ninth abdominal segment of the male. This is the segment that carries the intromittent organ and the clasping and other organs of copulation.

In the Diptera the hypopygium is nearly always more or less conspicuously enlarged and variously modified to subserve the purpose of coition.

The tenth segment is the segment that carries the anus, and is usually comparatively small and inconspicuous. It may, however, bear expanded or elongate lobes of various shapes. Such lobes are nearly always soft and flexible, and probably have no direct connection with the genital function of the ninth segment.

The segments immediately preceding the ninth are usually modified in a manner dependent on it. They may form a peduncle for the hypopygium; they may be distorted in shape and asymmetrical; they may be variously reduced and some of them even lacking.

Segments i to v or vi usually constitute the normal or pregenital part of the abdomen.

The writer is indebted to Professor J. M. Aldrich of the University of Idaho for named material on which the fol lowing descriptions are based.

The hypopygium of the Dipteran family Dolichopodidæ usually has the form of a laterally compressed oval or ovate capsule carried upon a flexible peduncle. The ventral part is deeply concave, the cavity thus produced being the genital chamber. From the anterior part of the roof of the genital chamber arises the penis. This is elongate and

slender. It curves forward and downward over the anterior wall of the chamber and then goes straight posteriorly a varying distance, extending to or beyond the posterior end of the hypopygium. Its lower part is generally guarded by a semicylindrical sheath arising from the lower part of the anterior wall of the genital chamber. From the posterior edges of the side walls of the latter there arise two pairs of hook-like clasping lobes. The body cavity in the hypopygium opens into that of the eighth segment, not by a foramen at its anterior end, but by an aperture situated on *the anterior part of the left side.* This is the distinctive character of the Dolichopodid hypopygium.

The eighth segment itself is small and scale-like, covering the lateral foramen of the ninth, and not extending beyond the anterior end of the latter. Its interior communicates with that of the seventh segment through a narrow vertical opening at its anterior end.

The seventh segment forms the peduncle of the hypopygium, being connected with it through the intervention of the eighth segment. Since the latter lies on the left side of the median line, the axis of the seventh segment is oblique.

The sixth segment is small, and usually not much modified, except that its tergum is larger than its sternum.

The pregenital part of the abdomen, *i. e.*, that part containing the principal abdominal viscera, consists of the first to the sixth segments inclusive. The sixth segment is generally retracted partly into the fifth. The hypopygium may be partly or entirely hidden in a groove on the ventral side of the segments before the seventh.

The tenth segment consists of a small median conical part placed at the upper posterior angle of the hypopygium, and of two large lateral lobes. The latter may be either wide and oval, or elongate and tapering.

The following detailed description of the abdomen of *Dolichopus crenatus* may serve as a type for the entire family. Descriptions of other forms are more briefly given beyond.

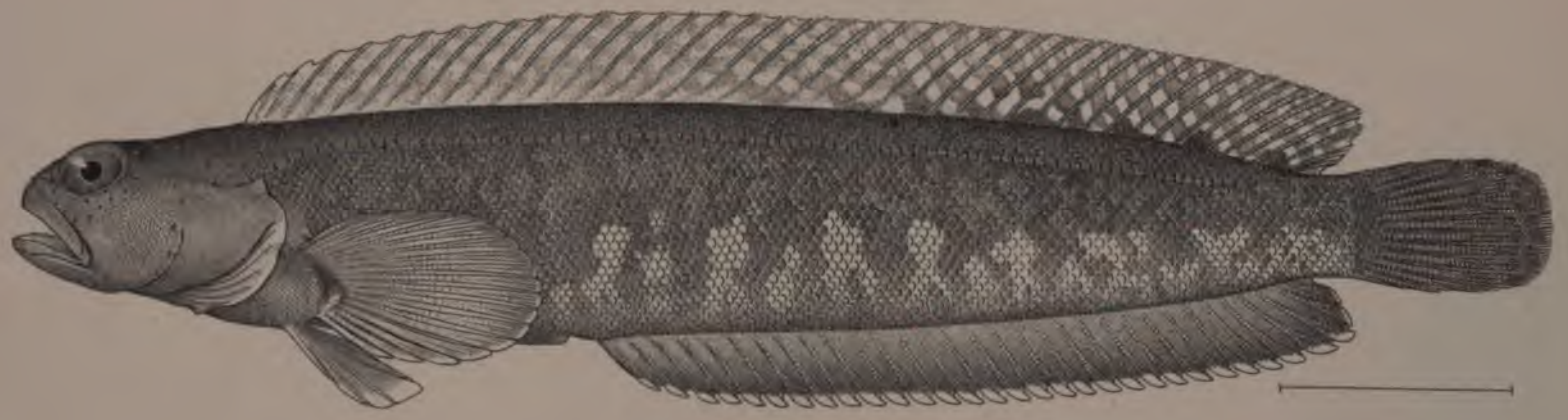
## Dolichopus crenatus *O. S.*

PLATE XXX, FIGS. 1–9.

The pregenital part of the abdomen is ovate in shape (fig. 1), broadly joined to the thorax, tapering posteriorly to a point formed of the fifth segment with the sixth mostly retracted within it. The sterna of segments iii to vi form a deep groove between the lower edges of the corresponding terga, in which is lodged the ventral part of the hypopygium, the latter being ordinarily bent forward and upward upon its peduncle. The fourth sternum is V-shaped with the apex directed forward, the space between the arms being membranous. The fifth sternum is entirely lacking. The sixth consists of a U-shaped bar open posteriorly. From the rounded apex of the latter a narrow median bar of chitin runs forward in the membranous roof of the groove to the angle of the fourth sternum.

The seventh segment forms the peduncle of the hypopygium. It is loosely united to the sixth by a wide flexible membrane (fig. 2), allowing considerable movement between the genital and pregenital parts of the abdomen. The tergum of the seventh segment (*t.*) is a transverse sclerite having the lateral parts produced downward and posteriorly. The latter meet the anterior part of the small median sternum (*s.*), which lies entirely posterior to the dorsal part of the tergum, and projects backward beneath the anterior end of the hypopygium and the anterior half of the eighth segment.

The eighth segment (figs. 2 and 3, viii) forms a flat scale-like plate, roughly triangular in outline, lying upon the anterior part of the left side of the hypopygium. Its form, as seen from the right, is shown in figure 7. It is evident that its true right side is reduced to the narrow vertical bar lying opposite the anterior edge of the left side. The posterior foramen is lateral, lying back of this bar, and occupying nearly all of the actual right side of the segment. The anterior foramen is a narrow vertical opening



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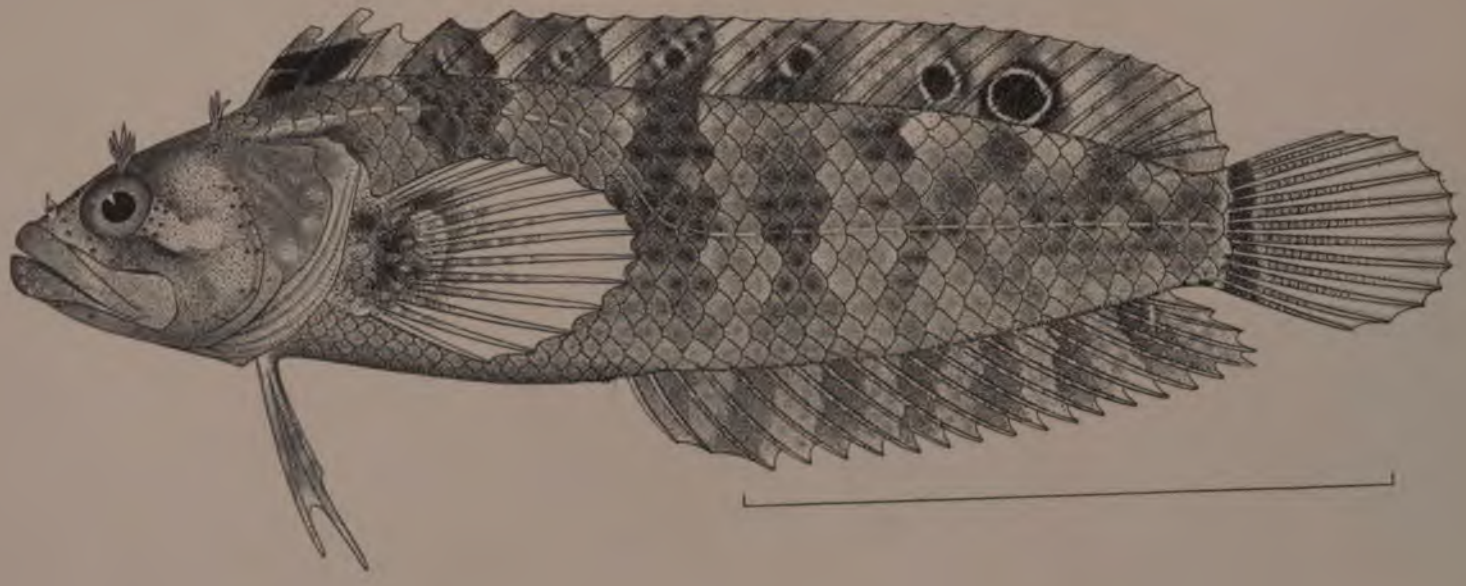

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CALIFORNIA ACADEMY OF SCIENCES

THIRD SERIES

ZOOLOGY VOL. III, NO. 10

# The Hypopygium of the Dolichopodidæ

BY

ROBERT E. SNODGRASS

WITH FOUR PLATES

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SAN FRANCISCO

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1904

is very small and two-segmented (fig. 9, *s. p.* and fig. 8). It lies beneath only the anterior third of the ventral part of the penis. Projecting downward at the side of the penis is a pair of large recurved hooks (fig. 9, *h.* and fig. 10). The posterior lateral clasping appendages of the hypopygium have the form shown in figure 7. The lobes of the tenth segment (fig. 9, x) are simple and oval.

### Gnamptopsilopus filipes *Loew.*

PLATE XXXIII, FIGS. 4-6.

In this species the seventh segment forms a narrow neck-like stalk for the hypopygium. Its tergum (fig. 6, *t.*) and its sternum (*s.*) are small, and are separated on each side by a rather wide membranous space. The eighth segment (fig. 6, viii) is elongate oval, the longer diameter longitudinal.

The posterior lower angles of the hypopygium are prolonged each into two long slender appendages (figs. 5 and 6, *d* and *d'*). These apparently correspond to the posterior ventral lobes (*d*) of the species so far described, but there are no clasping appendages present arising from the inner lateral walls of the genital chamber. The penis is inclosed in a large ventral sheath (figs. 5 and 6, *s. p.*), which forms a long curved cylindrical structure arising from the anterior lower angle of the hypopygium. It extends backward, entirely unprotected by the walls of the genital chamber, to the posterior end of the long posterior ventral hypopygial lobes. The penis is covered dorsally by a long thin plate (fig. 5, *d. s. p.*) fitting closely upon the dorsal side of the ventral sheath.

The two dorso-lateral lobes of the tenth segment (figs. 5 and 6, x and fig. 4) are united by their median edges almost to their posterior ends, leaving only two small flaring terminal flaps free. The inner posterior margin of each of these bears a close row of short curved spike-like hairs. On each lateral aspect of the undivided part is an oblique row of long stiff slender hairs (fig. 4).

## Liancalus hydrophilus *Aldrich.*

PLATE XXXIII, FIGS. 3 AND 8.

This species has a long slender cylindrical abdomen, the pregenital part formed of the first six segments. The sixth segment (fig. 3) is unusually large, having a well developed tergum and sternum. The seventh segment (fig. 8, vii, *t.* and *s.*) is almost rudimentary, consisting of a narrow chitinous ring formed of the tergum (*t.*) and sternum (*s.*), entirely concealed within the sixth segment. The eighth segment is relatively large, and is triangular in lateral view (fig. 8, viii). The upper margin is curved, but the lower is prolonged downward to a sharp point. It covers nearly the entire left side of the ninth. The latter (fig. 8, x) is small, and is irregularly quadrate in lateral view. The lower angles are prolonged into small triangular lobes (*d*). There are two lateral pairs of posterior clasping appendages (*a* and *b*) present. The penis and its sheath are entirely inclosed within the genital chamber.

The paranal lobes of the tenth segment are remarkable for their length (fig. 3). They form a pair of long tapering appendages sparsely covered with very long hairs, and when turned forward reach to the thorax. Ordinarily the hypopygium is almost entirely concealed within the sixth segment (fig. 3), so that the long anal lobes appear to arise from the end of the pregenital part of the abdomen.

## Porphyrops longipes *Loew.*

PLATE XXX, FIG. 10.

This species is very similar to *Liancalus hydrophilus*, especially in having the anal lobes long and tapering. The species is, however, in general, intermediate between *L. hydrophilus* and those species presenting the more ordinary structure. The anal lobes are not nearly so long as in *Liancalus hydrophilus*, and both the eighth and the ninth segments of the abdomen are exposed.

### Hydrophorus algens *Wheeler*.

PLATE XXXIII, FIGS. 2 AND 7.

In this species all the segments of the genital part of the abdomen are concealed within the posterior segments of the pregenital part. Only the lobes of the tenth segment project (fig. 7). The first four abdominal segments are normal. The fourth has the sternum prolonged backward. The fifth and sixth segments have the ventral parts small and the terga tapering downward on the sides. The seventh segment is reduced to a narrow ring.

The hypopygium is small and has the very unusual form shown in figure 2. The principal part is short, but the posterior lower angles are greatly prolonged downward and posteriorly. Each is split into two long cylindrical lobes (fig. 2, *d* and *d'*).

The eighth segment resembles that of *Liancalus hydrophilus*, being prolonged ventrally into a tapering point. The paranal lobes of the tenth segment are simple.

### Diaphorus mundus *Loew*.

PLATE XXXIII, FIG. 1.

Externally the abdomen of this species is similar to that of *Hydrophorus algens*. The hypopygium is not visible, being ordinarily retracted or bent forward into the fifth and sixth segments, and only the tips of the paranal lobes of the tenth segment project.

The hypopygium itself (ix) is somewhat anomalous. It is cup-shaped, the open face being posterior; the lower edge is longer than the upper, and the anterior end is hemispherical. The cavity of the cup is the genital chamber. Each lateral rim bears a wide triangular lobe (*d*) projecting posteriorly. From the inner face of each of these lobes a large arm-like appendage extends backward and downward (*a*). Each appendage bears terminally an inward-curved hook. The penis arises as usual from the

roof of the genital chamber. It curves downward and posteriorly, resting upon the floor of the genital chamber anteriorly; but posteriorly it curves upward and extends far beyond the end of the hypopygium (fig. 1, *p*). It is embraced by the two posterior clasping appendages (*a*) of the hypopygium. There is no sheath for the penis; the floor of the genital chamber projects backward beneath it in a small median point.

The eighth segment (fig. 1, viii) is circular, thin, and scale-like, lying upon the ninth in the ordinary position.

The tenth segment is inclosed within the posterior upper part of the genital chamber, the distal parts of the paranal lobes alone projecting (fig. 1, x).

STANFORD UNIVERSITY,
CALIFORNIA.

## ABBREVIATIONS USED IN THE FIGURES.

i-x ——first to tenth abdominal segments.[1]
*a* ——upper of two lateral posterior clasping appendages of hypopygium.
*b* ——lower appendage of same pair.
*b'* ——inner ventral process when there are three lateral posterior clasping appendages on each side of the hypopygium.
*b. p.*——base of penis.
*c* ——median dorsal posterior appendage of hypopygium.
*cur.*——curtain-like fold from lower edges of genital chamber.
*d* ——posterior ventral lobe of side walls of genital chamber.
*d. s. p.* / *dor.* }——dorsal sheath of penis.
*g. c.*——genital chamber.
*h.* ——hook-like appendages at side of penis.
*l. l.*——lateral sheaths of penis.
*p.* ——penis.
*s.* ——sternum.
*s. p.*——sheath of penis.
*t.* ——tergum.
*vent.*——ventral sheath of penis,=*s. p.*

[1] Except on plate XXXIII, figure 8, where x=ninth segment.

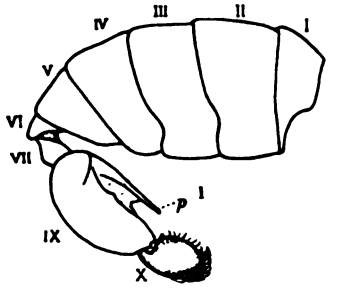
## EXPLANATION OF PLATE XXX.

*Dolichopus crenatus.*

Fig. 1. Right side of male abdomen.
Fig. 2. Left side of genital part of abdomen.
Fig. 3. Ventral view of genital part of abdomen.
Fig. 4. Left side of hypopygium.
Fig. 5. Posterior lateral clasping appendages of hypopygium, left side.
Fig. 6. Penis.
Fig. 7. Right view of eighth segment.
Fig. 8. Median dorsal posterior appendage of hypopygium.
Fig. 9. Tenth segment, ventral view.

*Porphyrops longipes.*

Fig. 10. Terminal part of abdomen, left side.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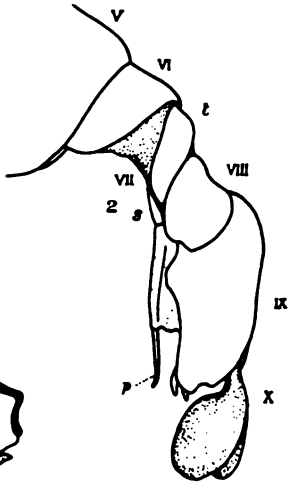
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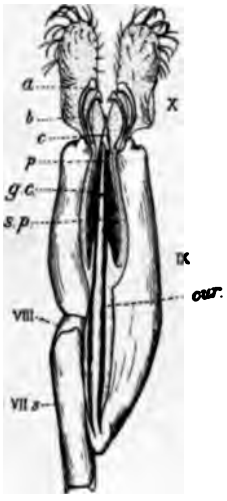
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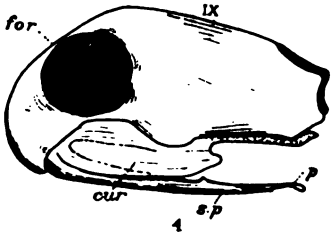
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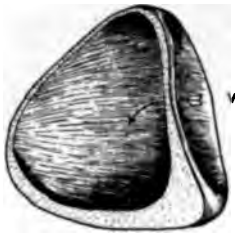
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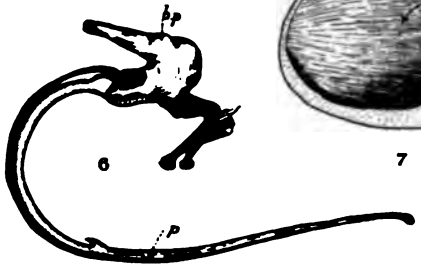
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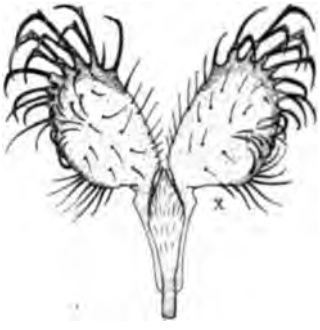
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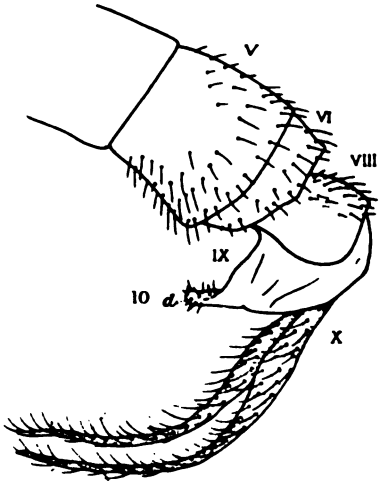
V
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X

## EXPLANATION OF PLATE XXXI.

*Dolichopus ovatus.*

Fig. 1. Left side of genital part of abdomen.

*Pelastoneurus vagrans.*

Fig. 2. Left side of abdomen.

*Dolichopus ovatus.*

Fig. 3. Lateral posterior clasping appendages and ventral posterior lateral lobe of hypopygium.

*Pelastoneurus vagrans.*

Fig. 4. Median posterior appendages of hypopygium.

*Neurigona superbiens.*

Fig. 5. Lateral posterior clasping appendages of right side of hypopygium, inner view.

*Pelastoneurus vagrans.*

Fig. 6. Lateral posterior clasping appendages and ventral posterior lobe of hypopygium.

*Psilopus sipho.*

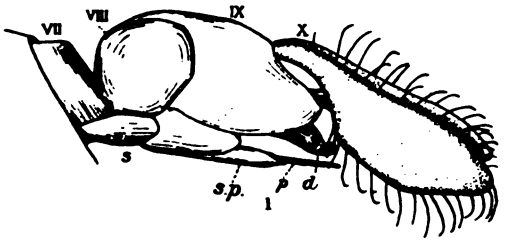
Fig. 7. Dorsal view of ventral part of penis and its sheaths.

*Neurigona superbiens.*

Fig. 8. Left side of abdomen.

*Psilopus sipho.*

Fig. 9. Left side of genital part of abdomen.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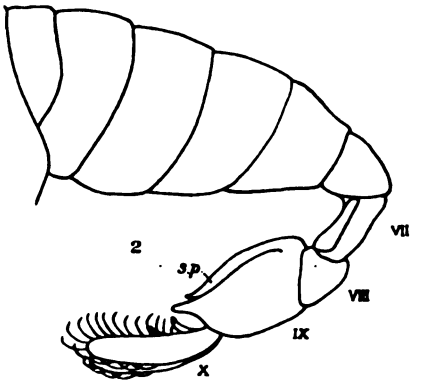
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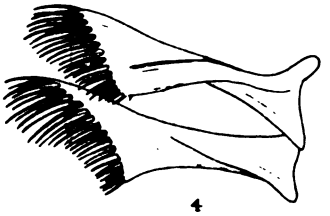
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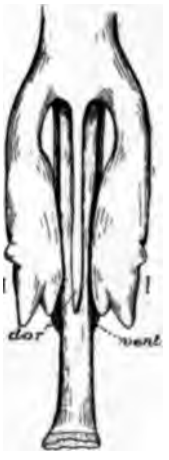
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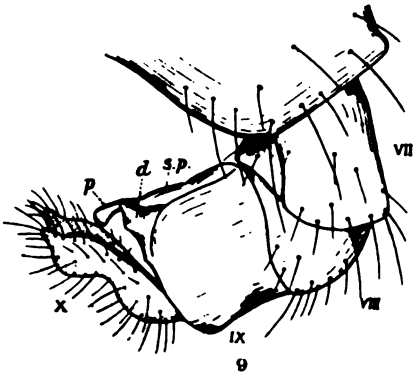
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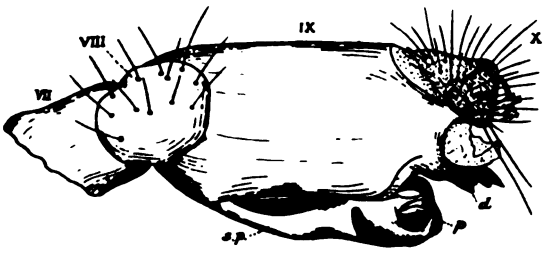


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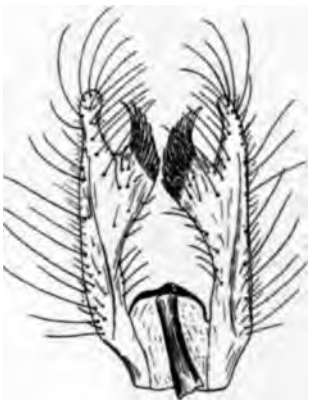

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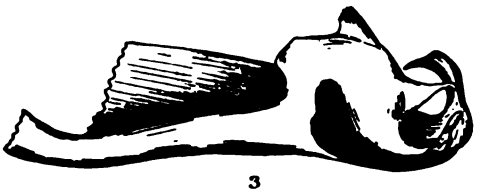

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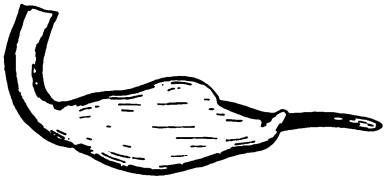

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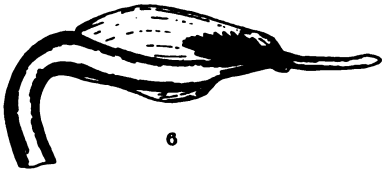

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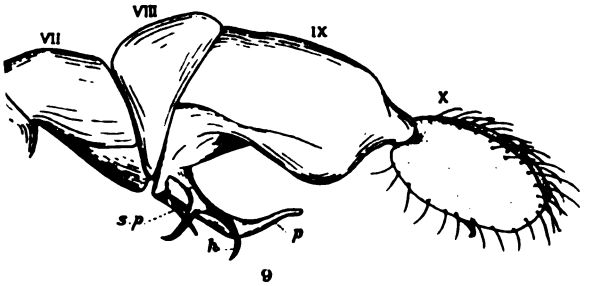


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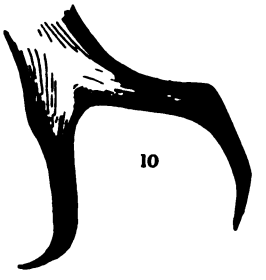

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PHOTO-LITH. BRITTON & REY, S.F.

## EXPLANATION OF PLATE XXXII.

*Pelastoneurus lætus.*

Fig. 1. Left side of genital part of abdomen.

*Psilopus sipho.*

Fig. 2. Paranal lobes of tenth segment, ventral view.

*Pelastoneurus lætus.*

Fig. 3. Left view of sheath of penis.
Fig. 4. Left view of ventral part of penis.
Fig. 5. Inner view of posterior lateral clasping appendages of right side of hypopygium.
Fig. 6. Right view of ventral part of penis.

*Tachytrechus vorax.*

Fig. 7. Posterior lateral clasping appendages of hypopygium.
Fig. 8. Sheath of penis.
Fig. 9. Left side of genital part of abdomen.
Fig. 10. Lateral hooks of penis.

## EXPLANATION OF PLATE XXXIII.

*Diaphorus mundus.*

Fig. 1. Left view of eighth, ninth, and tenth segments.

*Hydrophorus algens.*

Fig. 2. Left view of eighth, ninth, and tenth segments.

*Liancalus hydrophilus.*

Fig. 3. Left side of abdomen.

*Gnamptopsilopus filipes.*

Fig. 4. Fused lobes of tenth segment.
Fig. 5. Left side of hypopygium.
Fig. 6. Left side of genital part of abdomen.

*Hydrophorus algens.*

Fig. 7. Left side of abdomen.

*Liancalus hydrophilus.*

Fig. 8. Left side of genital part of abdomen.

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# Remarks on the Sexes of Sphæromids With a Description of a New Species of Dynamene

BY

SAMUEL J. HOLMES

WITH ONE PLATE

*Issued October 11, 1904*

SAN FRANCISCO

PUBLISHED BY THE ACADEMY

1904

# REMARKS ON THE SEXES OF SPHÆROMIDS WITH A DESCRIPTION OF A NEW SPECIES OF DYNAMENE.

BY SAMUEL J. HOLMES.

PLATE XXXIV.

THE GENERA of the family Sphæromidæ are in a state of annoying confusion. Differences of age and sex have led, in some cases, to the establishment of more than one genus for members of the same species. In cases where a marked sexual dimorphism is supposed to exist, little has been accomplished towards connecting the forms with their proper mates. And aside from this there is more than the usual amount of difference of opinion regarding the validity and the limits of the genera into which this family has been divided.

M. Hesse[1] who has devoted a memoir to the sexual relations of the Sphæromidæ came to the conclusion that he had made a discovery which would greatly simplify matters; *Sphæroma* he believes to be only the female form of *Cymodoce*, and *Dynamene* the female of *Næsa*. The evidence upon which Hesse bases both his conclusions is, however, all indirect. Regarding the first conclusion he makes the interesting observation that "depuis que notre attention s'est fixée sur ses Crustacés, c'est-à-dire depuis plus de vingt ans, nous n'avons *jamais* vu un seul Cymodocéen adulte qui eût des œufs, tandis que nous avons *toujours trouvé des Sphéromiens adultes qui en avaient*, et nous avons même pu suivre leur éclosion et élever les jeunes." But he adds: "Malheureusement nous n'avons pas pu mener

[1] Ann. Sci. Nat. ser. 5, t. 17, 1872.

jusqu'au bout notre épreuve; nous avons cependant conduit leur éducation jusqu'à la troisième mue: mais passé cette limite, soit que l'état de captivité dans lequel nous les tenions leur fût contraire, soit que le genre de nourriture que nous leur donnions ne leur convint pas, ils finissaient par mourir successivement sans avoir atteint l'âge adulte." Since *Sphæroma* and *Cymodoce* closely resemble each other in form and habit and are often found in the same localities, and since Sphæromas carrying eggs are often met with, while *Cymodoce* has never been observed to bear ova, Hesse includes both forms under the latter genus. Dr. Stebbing[1], who takes exception to Hesse's conclusion, remarks that "as between British species assigned to the two genera, there is no resemblance in color worth speaking of, and no community of residence, except that *Cymodoce* is occasionally and very rarely found on some of the shores that also yield *Sphæroma*. In *Sphæroma quadridentatum* Say, Mr. Harger has ascertained that neither sex is a *Cymodoce*. . . . I can, however, myself testify that *Sphæroma rugicauda* Leach need not have recourse to a *Cymodoce* for a male form." Whatever validity there may be in Hesse's conclusion regarding the specific identity of the forms studied by him, his general conclusion that *Sphæroma* represents the female form of *Cymodoce* certainly cannot be maintained. On the west coast of the United States *Sphæroma* is represented by several species. I have observed thousands of specimens of this genus in various localities from Oregon to Lower California, and have never seen a single *Cymodoce* associated with them. In fact, up to this time, there has been no species of *Cymodoce* described from the Pacific coast of North America. Moreover, by an examination of the sexual organs of three west American species, *Sphæroma oregonensis* Dana, *Sphæroma rhomburum* Richardson, and *Sphæroma pentodon* Richardson, and of *Sphæroma serratum* (Fabr.) from the Bay of Naples, I have ascertained that both males

[1] A History of Crustacea, N. Y. 1883.

and females occur in each of these species, and that they exhibit no marked degree of sexual dimorphism.

That *Dynamene* represents the female form of *Næsa* is a conclusion that has more in its favor. At least it may be true that some species of *Dynamene* may have males that would come under the genus *Næsa*. *Næsa bidentata* and *Dynamene Montagui* were regarded by Bate and Westwood[1] as probably the male and female of the same species. Dr. Stebbing considers it "not improbable that the species named *Dynamene rubra* and *Dynamene viridis* by Leach and *Campecopia versicolor* by Rathke, may represent the female, and *Dynamene Montagui* the young male of *Næsa bidentata*. . . . No one appears to have ever found the *Næsa* form or *Dynamene Montagui* carrying eggs, and, as they are not at all uncommon, they may therefore be presumed to be of the male sex." The form described and figured by Hesse, however, is certainly not *Dynamene rubra* or *viridis*, and it may be added that the specimen figured as the male of this species differs wonderfully from the figure given by Bate and Westwood. Moreover, the form figured as the female differs so markedly from the male that it would require much stronger evidence than Hesse has adduced to convince a reasonably skeptical person that the two forms represent the two sexes of the same species. The differences are not confined to the posterior part of the body but extend to the anterior thoracic segments and head. Hesse does not state under what name the female of this species was previously described or whether it had been described at all. While sexual dimorphism may exist in the forms Hesse describes, it may not unreasonably be doubted whether this writer has connected the male and female of the same species.

The attempt was made by Hesse to raise the young of *Dynamene* in order to ascertain whether they would give rise to any specimens of *Næsa;* but, as in the experiment with *Sphæroma*, the young all died before reaching a stage

[1] A History of the British Sessile-eyed Crustacea, v. 2, Lond. 1868.

sufficiently advanced to enable the question to be definitely settled. It apparently did not occur to Hesse to attempt to ascertain the sex of these forms by dissection. Arguments are adduced at considerable length to prove by circumstantial evidence that certain forms are males and others females, while not a single attempt to determine the sex of any specimen by direct observation is recorded. We do not certainly know but that Hesse's specimens of *Næsa*, *Dynamene*, and *Cymodoce* all contain both male and female forms. The question may easily be determined without having recourse to internal dissection, as the males of the Sphæromidæ may be recognized by the presence of a stylet on the inner ramus of the second pair of abdominal appendages.

As *Dynamene* is supposed to represent the female form of *Næsa*, Hesse assumes that it should rank as a synonym of the latter; all of the species he describes, some of which are known only from the female, or *Dynamene* form, are placed under the genus *Næsa*. According to the rules of the American Ornithologists' Union, which are largely followed in this country, if two names are given simultaneously to the same genus and are otherwise of equal pertinency, the name based on the adult male takes precedence over that based on the young male or female. *Nesæa* and *Dynamene* were both instituted by Leach in the article 'Crustaceology' in the 'Edinburgh Encyclopedia' in 1814. Other things equal, *Nesæa*, being based on the male form, would be retained; but other things were not equal, the names were not of equal pertinency, as *Nesæa* was preoccupied. *Næsa*, which was substituted for *Nesæa (nomen preocc.)* in 1818, becomes, if based as the male of *Dynamene*, a synonym of the latter genus. The same result would be arrived at by following most of the other codes of nomenclature now in vogue.

On the other hand, the retention of *Dynamene* may be objected to on the ground that, as no species were assigned to it, it was not properly defined, and should be considered indeterminate. According to canon 37 of the code above

referred to, "If an author describes a genus and does not refer to it any species, either then or previously described, the genus cannot be taken as established or properly defined, unless the characters given have an unmistakable significance." The definition of *Dynamene*, I believe, may be reasonably held to fulfill this requirement. The genus is characterized along with other genera from which it is accurately distinguished, so that there would be little difficulty in recognizing it even if species were not subsequently assigned to it by Leach himself. The original definition of the genus is as follows: "Eyes not reaching the anterior margin of the first segment; base of tail on each side with two equal foliaceous appendages, apex of the tail emarginate; nails bifid. There are several indigenous species of this genus, but the characters are not yet determined." Essentially the same definition is repeated without the assignment of any species in the 'Transactions of the Linnean Society' for 1818, but in the 'Dictionnaire des Sciences Naturelles' (t. 12, 1818) the genus is again defined and three species are assigned to it, *Montagui*, *rubra*, and *viridis* in the order named.

The name *Dynamene* may be further objected to on account of being nearly identical with *Dynamena*, which was described a few years before. How near one name must be to another to be rejected is a question which most codes of nomenclature leave to the discretion of individual writers. Are we to discard, as some writers do, such names as *Platymerus* because it is preoccupied by *Platymera*? or reject both because there is a still earlier name *Platymeris*? This is a subject concerning which it is unfortunate that different usages prevail, for this circumstance promises to give rise to much confusion when the validity of generic names is more critically looked into than is usually done at present. Names like the above, as well as numerous undoubted synonyms, have been suffered to stand simply because they have been neglected; but sooner or later judgment will be passed upon all such names, and the result will be that a large share of existing genera will

be discarded by some writers and retained by others. It is, I believe, a safe rule to follow, to allow a generic name to stand if it differs from the nearest preceding name both in spelling and pronunciation, be this difference ever so little. *Dynamene* would naturally be pronounced somewhat differently from *Dynamena*, and therefore ought not to be considered a synonym of the latter genus. Whether or not the two words are of the same derivation should not, I believe, be considered. For the purposes of zoological nomenclature a name is a name. If *Dynamene* is rejected on account of its similarity to *Dynamena*, new names should be substituted for *Dynomene* and *Dynamina* as well.

It is only after some hesitation that the following species have been referred to *Dynamene*. The females are congeneric with *Dynamene rubra* and *D. viridis*, and as these species are, I believe, members of a valid genus, the species here described should also be referred to *Dynamene*, although the males do not conform to the original definition of Leach.

### Dynamene sculpta sp. nov.

PLATE XXXIV, FIGS. 1-7.

*Male:* — Body increasing slightly in width posteriorly. Head narrowed and scarcely longer than the first segment of the thorax. Eyes oblong, situated on prominent, rounded, lateral lobes. Thoracic segments minutely roughened behind, the lateral angles produced backwards into subacute, triangular processes; first segment longer than the succeeding ones, the lower side produced forward into a triangular process extending a little in advance of the eye, and backward into a triangular, acute lobe at the postero-inferior angle; last 3 segments with several small setose prominences on the posterior margin. Abdomen large, with 5 segments indicated, the anterior segment marked off by a line extending entirely across the upper surface, the 3 following segments are indicated by 2 pairs of lines which are visible only at the sides; second segment furnished with 3 setose tubercles in a transverse row. Caudal shield large and sculptured, the anterior portion with 3 tubercles, the middle one rather blunt and a little in advance of the others; a pointed tubercle with 2 lateral ridges in front of the posterior notch; notch deep, with a small spine at the end, behind which is a pair of larger spines. Inner branch of the uropods flattened and not nearly reaching the tip of the caudal shield, the tip subacute; outer branch very long, narrow, and incurved, extending considerably behind the tip of the caudal shield and directed obliquely upwards. First antennæ a little shorter than the second,

the first basal joint enlarged, oblong, and emarginate at the distal end at the insertion of the small, subquadrate second joint; flagellum longer than the peduncle and composed of 9–11 joints. Second antennæ scarcely reaching the middle of the thorax, the peduncle slender, the last 2 joints much longer than the preceding ones; flagellum a little longer than the peduncle, the joints furnished with short setæ. Thoracic legs increasing slightly in length posteriorly and furnished with short hairs; propodi armed below with spines; dactyls curved and ending in a spine with a strong spine behind the tip.

*Female:* —The females are smaller than the males; the head, antennæ, mouth parts, thoracic legs, and anterior segments are not distinguishable from those of the male, but the abdomen is markedly different. The caudal shield is relatively smaller and less sculptured, the notch at the extremity is simple and shallow; there are 3 oblong tubercles on the anterior portion; the 3 tubercles on the next segment in front are smaller than in the male. The branches of the uropods are flattened and of subequal size; neither extends beyond the tip of the caudal shield.

Both sexes possess the power of rolling themselves up, but they do not take on so nearly a spherical form as that assumed by the species of *Sphæroma*. This species was taken from pieces of sponge dredged in shallow water at San Clemente Island, August, 1893. In July, 1895, I collected several specimens at San Diego, California. The 2 sexes were found together and were associated with no other species of Sphæromid. It was inferred from the association of these forms and their similarity in all external features except in the posterior part of the body, that they represented the male and female of the same species, but this conclusion was confirmed by the dissection of several specimens. The males, however, may be distinguished in this species, as in other Sphæromids, by the possession of a stylet on the second pair of pleopods. None of the females were found bearing eggs, though the ovaries were well developed and the vasa deferentia of the males were distended with spermatozoa.

The male of this species is very closely allied to the form recently described by Miss Richardson[1] as *Cilicæa caudata gilliana*. It differs in having a single median spine, instead of a pair of spines, at the anterior end of the emargination of the caudal segment, and in having usually but a single pair of teeth, instead of three pairs, at the sides of this emargination. In some cases, however, the posterior angles of the emargination may be dentiform and partly included so as to give rise to two pairs of lateral teeth. The inner branch of the uropods presents a prominent angle which stands some distance away from the sides of the caudal segment, while the point of the ramus in *caudata*

[1] Proc. U. S. Nat. Mus. v. 21, p. 840, fig. 17, 1899.

*gilliana* is apparently concealed under the lateral margin. There are three tubercles instead of five at the base of the abdomen, although there are sometimes traces of another tubercle on either side of the lateral ones.

The females bear considerable resemblance to Miss Richardson's *Dynamene dilatata*, but the body is narrower, the epimera smaller and pointed at the sides, and the caudal shield more elongated.

## Dynamene cordata (*Richardson*).

PLATE XXXIV, FIGS. 8-10.

*Cilicaea cordata* RICHARDSON, PROC. U. S. Nat. Mus. v. 21, p. 839, fig. 16, 1899.
*Dynamene tuberculata* RICHARDSON, *l. c.* p. 833, fig. 9.

*Male*:—Body tapering from behind forwards. Head somewhat produced in the middle, the anterior margin thickened and forming a broad lobe on either side of the prominent rounded frontal projection. Eyes situated on postero-lateral lobes of the head, which are produced backwards. First antennæ shorter than the second, the first joint oblong, having an acute process projecting below the small second joint; third joint slender and subcylindrical; flagellum 9-12 jointed, reaching beyond the posterior margin of the head. First thoracic segment longer than the succeeding ones, which are of subequal length. Epimera bent abruptly downwards and produced backwards into narrow but rounded points. On the posterior margins of the last few thoracic segments, especially in old specimens, is a transverse row of small double tubercles which increase in size posteriorly.

First abdominal segment with 5 double tubercles. On the convex base of the large caudal segment is a transverse row of 3 double tubercles, the cusps in the central tubercle situated in a transverse line, those in the lateral tubercles placed the one before the other. The deep median posterior emargination is armed with 3 pairs of teeth, the pair near the apex small; middle pair often double. A prominent tubercle near the apex of the emargination. Inner ramus of the uropods lamellate, concave above, distally acute, and much shorter than the caudal segment; outer ramus large, incurved, expanded on the inner side of the base into a lobe which fits under the inner ramus. The distal portion of the outer margin armed with 4 or 5 tubercles; the tip often turned slightly outwards, and extending somewhat beyond the extremity of the caudal segment.

Length of largest specimen 15 mm.

*Female*:—A detailed comparison of the mouth parts, antennæ, and other appendages revealed no differences between the forms considered to represent the 2 sexes of this species. The head of the males is a little more produced in front than in the females. The significance of this difference

is that the head of the male is especially adapted to fit into the under side of the large caudal segment, the 2 parts fitting together very neatly when the animal is rolled up.

There is a similar adaptation between the head and caudal segment of the female, the head being somewhat differently shaped in relation to the form of the parts against which it abuts. Aside from this, the sexual differences are confined to the posterior portion of the body. In the female the 3 tubercles on the convex basal portions of the caudal segment are less prominent than in the male, and the posterior emargination much less deep and devoid of lateral teeth. The rami of the uropods are of subequal length and flattened, and considerably shorter than the caudal shield. The tubercles on the first abdominal segment are less prominent, and those on the posterior margins of the last thoracic segments may be absent entirely. The whole posterior portion of the body is much less developed in the female than in the male. In immature females the caudal shield is relatively longer than in the adult, the basal portion less tumid, the posterior flattened portion relatively longer, and the tubercle near the apex of the posterior emargination frequently absent. Figure 9 is taken from an immature female collected at Monterey, November, 1895. Larger females taken at San Clemente in the summer of 1894 agree perfectly with Miss Richardson's figure of *D. tuberculosa.*

Specimens of both sexes were taken at San Diego, San Pedro, San Clemente Island, and Monterey. Both at San Pedro and at Monterey I have collected numerous specimens from the fronds of kelp. At the latter place they were found in great abundance, and the similarity of habitat and coloration shown by the two forms led to the surmise that they were the two sexes of the same species. This surmise led to the examination of a large number of each of the forms, and it was found that all of the one form were males and all of the other females.

*Dynamene cordata* is reported by Miss Richardson from Catalina Island, Monterey, and Popof Island (Aleutian Islands). The female form which Miss Richardson describes as *Dynamene tuberculosa* is reported from Catalina Island, Gualala, and Bodega Bay, California, and Popof Island, Alaska. I have retained the specific name *cordata*, rather than *tuberculosa*, because it was applied to the male form. The fact that the generic name *Cilicæa*, as it was founded after *Dynamene*, cannot be retained in this case, has nothing to do with the validity of the specific name.

### Dynamene glabra *Richardson.*

*Dynamene glabra* RICHARDSON, Proc. U. S. Nat. Mus. v. 21, p. 834, fig. 11, 1899.

Specimens of this species were collected at Mendocino County, California, and at San Diego, California. The emargination of the caudal shield in this species is shallow and the caudal shield is very similar to that found in some species of *Sphæroma*. In *Sphæroma rhomburum* Richardson the sides of the caudal segment are folded down, forming a sort of groove on the lower side as in the present species. In *Sphæroma octoncum* Richardson there is a similar groove on the lower side of the shield and the apex is almost emarginate. In the females of *Dynamene sculpta* the posterior sinus is often very shallow, so that the genus *Dynamene* seems connected with *Sphæroma* by various transitional stages. *Dynamene glabra* shows a noteworthy point of agreement with *Sphæroma* in that the sexes do not show the marked dimorphism found in the two preceding species. An examination of several specimens of this species showed that the males present no appreciable external differences from the females except that, as a rule, they are of somewhat larger size.

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## EXPLANATION OF PLATE XXXIX.

Fig. 1. *Dysmicoccus insignis*, male. Side view of head.
Fig. 2. *Dysmicoccus insignis*, male. Tarsi of the metathoracic legs.
Fig. 3. *Dysmicoccus insignis*, male. Fore antenna.
Fig. 4. *Dysmicoccus insignis*, male. Second antenna.
Fig. 5. *Dysmicoccus insignis*, male. Last thoracic leg.
Fig. 6. *Dysmicoccus insignis*, male. Abdomen seen from above. As the long setæ of the exopodic pairs obliquely upwards it appears foreshortened in the figure.
Fig. 7. *Dysmicoccus insignis*, female. Abdomen seen from above.
Fig. 8. *Dysmicoccus orchidis*, male. Abdomen seen from above.
Fig. 9. *Dysmicoccus orchidis*, female. Abdomen seen from above.
Fig. 10. *Dysmicoccus insignis*, male. Antenna.

Figures 1, 3, 4, 5, 7, 8, 9, 10 drawn to the same scale. All the figures were drawn with the aid of a camera lucida.

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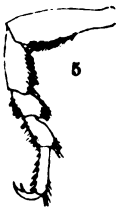
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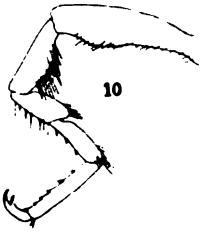
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# On Some New or Imperfectly Known Species of West American Crustacea

BY

SAMUEL J. HOLMES

WITH THREE PLATES

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# ON SOME NEW OR IMPERFECTLY KNOWN SPECIES OF WEST AMERICAN CRUSTACEA.

BY SAMUEL J. HOLMES.

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PLATES XXXV-XXXVII.

IN THE present paper, while a few new species have been added, most attention has been given to the description of forms which have been very briefly characterized or given wrong generic or specific names. As I have had the opportunity of examining the types of several inadequately described species, it was thought best to redescribe and figure these forms so that their identification might be rendered a somewhat less hazardous undertaking. In a few cases the recognition of the species from the original description would be a practical impossibility; yet it is not customary to consider a species indeterminate if its type be extant, and there is danger, especially if the species is assigned to a wrong genus or family, that it will be unsuspectingly redescribed under a new name. This source of error at least will be largely eliminated by a fuller knowledge of these forms.

Most of the material upon which this paper is based was obtained from the California Academy of Sciences through the kindness of the former president of the Academy, Professor William E. Ritter.

# Order THORACOSTRACA.

## Suborder DECAPODA.

## Tribe BRACHYURA.

### Uca brevifrons *(Stimpson).*

PLATE XXXV, FIGS. 1-5.

*Gelasimus brevifrons* Stimpson, Ann. N. Y. Lyc. Nat. Hist. v. 7, p. 229, 1860. Smith, Trans. Conn. Acad. Sci. v. 2, p. 131, 1870. Lockington, Proc. Calif. Acad. Sci. v. 7, p. 148, 1877.

*Gelasimus vocator* Kingsley, Proc. Acad. Nat. Sci. Phila. 1880, p. 147 (in part).

*Uca vocator* Ortmann, Zool. Jahrb. Abth. f. Syst. 10 Bd. p. 352, 1897 (in part).

Carapace convex, minutely punctated and microscopically granulated, the branchial regions more or less plainly marked with small tubercles near the outer edge; the H-shaped impression is prominent and the branchial regions are marked with a faint longitudinal groove. Front broad, not strongly produced forward. Upper edge of the superior margin of the orbit marked with a prominent raised line, lower edge with a strong convexity midway between the front and the lateral angles. Lateral angles almost right angles, and slightly, or not at all produced forwards. Lateral margins of the carapace for a short distance nearly parallel, arching slightly outwards, and then converging quite strongly to the posterior margin. A conspicuous groove just behind the anterior margin of the carapace extending from the sides about half way to the middle line. Orbital grooves deep, the lower margin of the orbit curved from the inner end and furnished with short, rounded spines which become larger around the outer angle. Eyes not reaching the outer angles of the carapace. Merus of the external maxillipeds nearly as long as wide, and $\frac{2}{3}$ the length of the ischium, the lower margin but slightly oblique. Merus of the large cheliped with the outer surface marked with transverse, sparingly setose striæ, the inner surface smooth; carpus long, the outer surface roughened with small, blunt tubercles; inner surface smooth, rhomboidal in outline, the upper margin armed with a few blunt tubercles; hand large and stout, nearly twice as long as the width of the carapace, upper surface with small tubercles which gradually become smaller further down on the outer surface; upper margin of the palm raised, the narrow space between this margin and the carpal groove tuberculated; lower side of the palm marked with a fine raised line which fades out on the base of the pollex; carpal groove moderately deep, continued anteriorly as a shallow narrower groove to the base of the dactyl; the inner surface of the palm is marked with a short, very prominent, tuberculated ridge which runs from near the lower margin towards the supero-proximal portion of the hand; from the upper end of this ridge there is a short tuberculated ridge

extending towards the base of the dactyl; the prominent lower margin of the carpal groove extends backwards from the angle where these ridges meet in the same direction as the upper ridge; the meeting point of the 3 ridges forms the apex of a large, high, three-sided pyramid. A line of small granules extending backwards from the inner margin of the pollex and dividing into 2 branches which run on either side of a groove lying behind the base of the dactyl; pollex gently curved, the inner margin granulated on the basal portion and armed with a few teeth on the distal half; tip truncated; dactyl curving from near the middle, overreaching the pollex, the inner margin granulated and furnished with a few small teeth. Ambulatory legs slender and hairy, the meral joints narrow and marked with scattered, sparingly setose striæ; dactyls slender, smooth, sulcated, and about as long as the propodi. Abdomen in the male broad, the third, fourth, and fifth segments successively increasing in length and decreasing in width; sixth segment a little narrower than the fourth but about as long. There is a dense tuft of fine hair on the posterior side of the coxa of the second, and on the anterior side of the coxa of the third pair of ambulatory legs.

Color of the carapace in alcohol dark olivaceous.

| | Male. | Female. |
|---|---|---|
| Length of carapace | 20.5 mm. | 18 mm. |
| Posterior margin of carapace | 15 mm. | 15.5 mm. |
| Breadth of carapace | 29 mm. | 25 mm. |

Length of large hand 55 mm.; merus 18 mm.; carpus 15 mm.

Todos Santos, Lower California, in a lagoon (Stimpson); Magdalena Bay (Lockington); San José del Cabo, Lower California, from fresh water.

Described from numerous specimens from the last locality, collected by Eisen and Vaslit.

*Uca brevifrons* has been united with *U. vocator* (Herbst) by Kingsley and more recently by Ortmann; but it differs from Herbst's description of *vocator* and from all the other species which Kingsley and Ortmann regard as synonyms of that form. From *pugnax* (Smith), *brevifrons* differs in its broader and less projecting front, in the much more convex lower border of the upper orbital margin, in having the inner surface of the carpus of the larger cheliped devoid of an oblique tuberculated ridge, in the more slender meral joints of the ambulatory legs, and in its larger size.

From *U. crenulata* (Lockington) which has also been erroneously united with *vocator*, it differs in its relatively narrower carapace with a shorter posterior margin, the

more convex lower border of the upper orbital margin, the longer merus of the external maxillipeds, and in its much larger size, different granulation and coloring. The two species are very different.

From *palustris* (Milne-Edwards) this species is distinguished by the broader terminal segment of the abdomen, the different markings on the inner surface of the larger hand and the wider gap between the fingers. It resembles *U. minax*, but has a broader and less convex carapace; the meral joints of the ambulatory legs are narrower and the carpus of the larger hand is not crested on the inner side. It is not quite certain that the forms which Lockington referred, somewhat doubtfully, to *brevifrons* really belong to this species.

## Tribe MACROURA.

### Family CALLIANASSIDÆ.

### **Lepidophthalmus** gen. nov.

Carapace laterally compressed and provided with a rostrum. Eye stalks flattened and scale-like, the eyes not rudimentary. Antennules with a long flagella. External maxillipeds with the ischium and merus operculiform and the second joint of the palp large and much dilated. First pair of thoracic legs unequal and chelate, the carpus and hand much wider than the preceding joints; second pair strongly compressed and furnished with small chelæ; third pair with the propodus flattened and expanded and furnished with a dense felt of short hairs, the dactyl small. First abdominal segment with a pair of uniramous appendages in both sexes; second pair of pleopods biramous and slender, the 3 following pairs broad and foliaceous. Uropods firm, not membranous or flexible, the outer ramus broad and thick, the inner ramus very much smaller than the outer. Telson short and firm.

This genus is quite closely allied to *Callianassa*, but differs in having the second joint of the palp of the external maxillipeds much dilated and in having the rami of the uropods firm and very unequal instead of membranous and of subequal size.

## Lepidophthalmus Eiseni sp. nov.

PLATE XXXV, FIGS. 6–13.

Rostrum small but prominent, acuminate, rounded above, and somewhat upturned. The antero-lateral regions of the carapace are strengthened by a more or less calcified area, the posterior margin of which is slightly raised and in the form of a letter S; a similar partly calcified area on the supero-posterior portion of the branchial regions; the margin of the branchial regions is thickened, and separated from the main portion by a thin flexible membrane; just in front of the postero-lateral angle this thickened margin is expanded into a smooth, rounded sclerite in front of which the margin is thin and membranaceous. Ocular peduncles oblong, the inner margins straight and contiguous until a short distance behind the acute tips; corneæ large, occupying most of the peduncles; a prominent rounded tubercle at the anterior end of the corneæ next to the inner margin. Antennules with the first joint short, the third slender and tapering, somewhat over twice the length of the second, and furnished below with long hairs; flagella subequal to the peduncle, the upper flagellum nearly naked and slightly shorter than the lower one which is furnished with numerous long hairs on the lower side. Antennæ much longer than the antennules, but scarcely twice as long; first joint with the outer margin produced into a rim which projects over the opening of the green gland; last joint of the peduncle longer and much more slender than the preceding; the tip of the peduncle reaches a little beyond the middle of the last joint of the peduncle of the antennules. External maxillipeds with the ischium and merus broadly expanded, the merus much wider than long; first joint of the palp distally widened; second joint very large and flattened, the inner side strongly produced, the terminal joint small, curved, and articulated to the outer angle of the preceding one.

Chelipeds unequal, smooth and glossy; the ischium of the larger cheliped finely serrated below, with a slight convexity near the distal end which is furnished with a few small spines; merus with the inner and outer sides flattened and converging below; lower margin with a rounded portion which is furnished with hairs and several small teeth; a prominent curved spine on the outer side at the proximal end; carpus wider than long, the posterior angle evenly rounded, the margins somewhat incurved; hand in the male much longer than the carpus, a broad, roughened, shallow, hairy groove extending backward from the gap between the fingers upon the outer side of the palm, inner side with a roughened hairy area extending backward to a rounded elevation at the base; a few teeth between the bases of the fingers; a prominent tooth on the outer side of the inner margin of the pollex; dactyl with several prominent teeth, the tip curved. In the female the larger hand is similar to that of the male but there is no roughened patch on the inner side of the palm, and the roughened groove on the outer side is short and indistinct; there is a notch on the inner margin of the pollex but no prominent tooth, the inner margin of the dactyl, like that of the pollex, is minutely serrated but bears no teeth; the tip is curved as in the male. The small cheliped is much the same in both sexes, but the carpus is relatively somewhat shorter in the male; the ischium is very minutely serrated on the

lower margin which is devoid of spinules; merus with the outer side rounded and the lower margin smooth and armed with a single small spine near the base; carpus like that of the larger cheliped; hand narrower than that of the larger cheliped, somewhat contracted near the base of the fingers; fingers hairy, much longer than the palm, the inner margins not dentate; the pollex tapers from the base, but the dactyl is of the same width from the base to within a short distance from the tip; tips of the fingers curved and crossing when closed. A small tooth at the distal end of the lower margin of the ischium of the 2 following pairs of legs; coxa of the fourth pair enlarged and flattened horizontally, the outer margin sharp and rounded. First pair of abdominal appendages in the male small and uniramous; second pair biramous, the rami slender. The first pair of pleopods in the female is much larger than in the male but uniramous and nearly as long as the second pair which is very similar to that of the other sex; the following pairs are broad and foliaceous, with the outer margins incurved and furnished with hairs. Uropods with a large tooth on the peduncle over the interval between the rami; outer ramus large, thickened, armed with a small, sharp spine at the base, the anterior portion thickened at the base and sloping distally where it is covered with a dense felt of short hairs; posterior portion smooth and limited anteriorly by the abrupt and slightly overhanging edge of the thickened area; inner ramus oblong, very much smaller than the outer, and gliding on the smooth posterior portion of the latter. Telson very short, much broader than long, the middle portion of the posterior margin convex, the outer angles prominent but rounded. The sides of the third, fourth, and fifth abdominal segments are furnished with patches of fine hair.

Length of female specimen 115 mm., carapace 28 mm., large arm 50 mm., hand 20 mm., carpus 12 mm., small arm 40 mm., hand 17 mm., carpus 8.5 mm., telson 8 x 11 mm. Length of male specimen 110 mm., carapace 27 mm., large arm 60 mm., hand 27 mm., carpus 14 mm., small arm 45 mm., hand 22 mm., carpus 8 mm.

Three specimens, one male and two females, from San José del Cabo, Lower California, collected by Dr. Eisen. The types are in the possession of the California Academy of Sciences.

## Family CRANGONIDÆ.

### Crangon Lockingtonii sp. nov.

PLATE XXXV, FIGS. 14–16.

*Crangon munitus* Lockington (not Dana), Bull. Essex Inst. v. 10, p. 159, 1878.

Rostrum oblong, concave above, rounded in front and arching over the eye-stalks. Two strong spines on the median carina of the carapace; 2 pairs of spines opposite the interval between the median ones, the 4 situated in the same transverse line; suborbital and antennal spines well developed; a

spine behind the antennal spine and in front of and external to the outer one in the transverse row; all the spines are prolonged posteriorly into a carina. Ocular peduncles short and stout, with a prominent rounded tubercle on the upper side at the margin of the large cornea. Antennules with a triangular tooth at the distal end of the first basal joint; outer flagellum flattened; inner flagellum much more slender than the outer one and scarcely half as long. Antennal scale short and broad, scarcely ½ the length of the carapace; peduncle nearly reaching the tip of the acicle. Anterior chelipeds stout, a spine on the lower side of the merus; carpus with a spine on the outer portion of the lower surface; hand oblong, inflated, about twice as long as wide, the margin against which the dactyl closes evenly convex and oblique, somewhat more nearly longitudinal than transverse; pollex spinous, oblique. Second pair of chelipeds very slender, about reaching the tip of the first pair. Abdominal segments rounded above. Telson rounded above but slightly flattened towards the base, much longer than the last abdominal segment but shorter than the carapace; the upper side is armed with 2 pairs of spinules; tip rounded and furnished with several long setæ.

Length of body 21 mm., carapace 6 mm., telson 4 mm., acicle 2.5 mm.

Described from the two specimens from Magdalena Bay, Lower California, which Lockington referred to *munitus*.

Type No. 3168 of the collection of the California Academy of Sciences; original number 109.

This species differs from *C. munitus* Dana in having a longer rostrum, much shorter inner flagellum of the antennules, stouter hand, longer sixth abdominal segment, and more slender uropods.

## Order ARTHROSTRACA.

## Suborder AMPHIPODA.

### Family LYSIANASSIDÆ.

### **Anonyx nugax** *(Phipps).*

PLATE XXXV, FIGS. 17–19; PLATE XXXVI, FIG. 20.

*Cancer nugax* Phipps, Voy. North Pole, p. 192, pl. 12, fig. 3, 1774.
*Anonyx nugax* Miers, Ann. Nat. Hist. (4), v. 19, p. 135, 1877.
*Lysianassa Fisheri* Lockington, Proc. Calif. Acad. Sci. v. 7, p. 48, 1877.

I have examined Lockington's type specimen of *Lysianassa Fisheri* which was taken on the northern coast of Alaska. The specimen was dried and imperfect when it came into Mr. Lockington's hands; after soaking it for

some time in dilute formalin I found that its condition for study was much improved and more details were made out than would otherwise have been possible. Having been very briefly described and placed in a wrong genus it would scarcely be possible, except by an examination of the type, for this species to be identified.

Specimens of *Anonyx nugax* from the Arctic seas north of Europe differ in no essential feature from Lockington's type.

## Family AMPHITHOIDÆ.

### Amphithoë scitula *(Harford).*

PLATE XXXVI, FIGS. 21–24.

*Dexamine scitulus* Harford, Proc. Calif. Acad. Sci. v. 7, p. 116, 1877.

Rostrum absent. Upper antennæ nearly as long as the body, the first 2 joints of subequal length; third joint about ⅔ the length of the second and nearly reaching the middle of the last basal joint of the lower antennæ; flagellum much longer than the peduncle and composed of about 70 joints. Lower antennæ about ¾ the length of the upper; third joint not longer than wide, but longer than the preceding joints which are very short; last joint of the peduncle about ¾ the length of the preceding one; flagellum but little longer than the peduncle and composed of 26 joints. Mandibles with the molar tubercle prominent; the second joint of the palp narrow, the third joint wider than the second, tapering evenly toward the base, the nearly transverse distal margin furnished with setæ. Outer plate of the first maxillæ armed with 10 curved teeth; first joint of the palp longer than wide, the second distally widened. Second maxillæ with the inner plate narrower than the outer but nearly as long and setose on the entire inner margin. Maxillipeds with the inner plate very small, oblong, distally rounded, not reaching the middle of the first joint of the palp; outer plate moderately wide, reaching beyond the tip of the second joint of the palp, the inner margin armed with about 20 spines; first joint of the palp about half the length of the second, inner margin very short; third joint pyriform; fourth joint slender, tapering, and ending in a claw-like seta. Second, third, and fourth epimera subquadrate and increasing successively in length and breadth. First gnathopods with the elongated first joint produced into a rounded lobe at the antero-distal angle; second joint with an anterior lobe; third joint truncated distally, the postero-distal angle rounded and setose; fourth joint subtriangular, elongated, nearly as long as the hand, and strongly setose posteriorly; hand oblong, slightly widened distally, the palm convex and very oblique. Second gnathopods shorter and stouter than the first, the first joint with a lobe at the infero-distal angle which is similar to but smaller than that of the first pair; second joint with a prominent anterior lobe; third joint similar to that of the first pair, the inferior angle produced

downward and thickly setose; fourth joint subtriangular, with a very prominent, rounded, thickly setose posterior lobe; hand similar to that of the first gnathopods but wider and having the palm somewhat less oblique. First pereiopods with the first joint broad, the postero-distal angle broadly rounded; second joint short; third and fourth joints rather wide, the third the longer; fifth joint tapering, slightly curved, and a half longer than the fourth; dactyl about half the length of the propodus. Second pereiopods similar to the first, the first joint convex on both margins. Third pereiopods with the side plate broad, quadrate, with a small posterior lobe whose lower margin is about at right angles to posterior side of the anterior portion; first joint very broadly ovate; third joint a half longer than the fourth; dactyl swollen at the base. Fourth pereiopods much longer than the third, the first joint oblong, convex anteriorly, the posterior margin convex above and concave below; second joint longer than wide; third, fourth, and fifth joints narrow and elongated; dactyl similar to that of the third pair; fifth pereiopods similar to the fourth, the first joint narrower but otherwise similarly shaped. Pleopods long, the rami nearly twice the length of the peduncles. First pair of uropods with the peduncle longer than the rami, reaching further back than the end of the sixth segment of the pleon, the upper margins armed with spines; outer ramus a little shorter than the inner; both are armed with spines on the upper side and a fascicle of spines at the tip. Peduncles of the second pair of uropods spiny above and reaching a little further back than the peduncles of the first pair; rami subequal to the peduncle in length, the outer a little the shorter. Peduncle of the last pair stout, flattened above, reaching a little beyond the middle of the rami of the preceding pair, the supero-distal margin finely denticulated; rami short, subequal, about half the length of the peduncle, outer ramus with 2 small, terminal spines; inner ramus flattened, tapering. Telson short, obtusely pointed.

Length nearly 1 inch.

This description is taken from Mr. Harford's type specimen of *Dexamine scitulus* from Magdalena Bay, Lower California. The eyes had lost their pigment and their outline could not be clearly made out. The specimen still retains traces of the beautiful purple color described by Mr. Harford.

## Family OEDICERIDÆ.

### Acanthostepheia behringanus *(Lockington).*

PLATE XXXVI, FIGS. 25-28.

*Œdicerus behringiensis* Lockington, Proc. Calif. Acad. Sci. v. 7, p. 47, 1877.

*Acanthostepheia pulchra* Miers, Ann. and Mag. Nat. Hist. 5th ser. v. 7, p. 47, pl. VII, figs. 1 and 2, 1881.

*Acanthostepheia Malmgreni* Stuxberg (not Goës), Evertebratfaunan i Sibiriens Ishaf. Vega-Expeditionens Vetenskapliga Jakttagelser, Bd. 1, pp. 724, 729, (wood cut). Della Valle, Fauna and Flora des Golfes von Neapel, 20 Monogr., Gammarini, p. 544, 1893 (in part).

Thoracic segments with a median carina on the posterior portion of the upper surface, the carina of the last segment interrupted in the middle and produced into a tooth at the posterior end; postero-lateral angles of the last 4 thoracic segments produced backwards and rounded. First 4 segments of the abdomen carinated above, the carinæ on the first 2 segments interrupted in the middle and produced posteriorly into a tooth; carina of the third segment continuous and terminating posteriorly in a narrow tooth which points obliquely upwards; anterior portion of the fourth segment smooth above and having a depression behind which is a tooth which is followed by a carina which extends to the posterior end of the segment where it may be produced into a small tooth; fifth and sixth segments very short above and smooth, postero-lateral angles of the first 3 abdominal segments very broadly rounded.

Head carinated above, the carina continued upon the long rostrum which is acute and strongly curved downwards; antero-lateral angle of the head acute, the margin above the angle concave. Eyes large, oval, situated in the base of the rostrum and almost contiguous above. Upper antennæ about $\frac{2}{3}$ the length of the lower and nearly $\frac{1}{2}$ the length of the body; first joint of the peduncle elongated, reaching nearly to the tip of the rostrum; second joint a little over half the length of the first and much more slender; third joint $\frac{1}{2}$ the length of the second; flagellum a little shorter than the peduncle. Fourth basal joint of the lower antennæ extending beyond the first joint of the upper for about $\frac{1}{3}$ its length; fifth joint more slender and somewhat longer than the fourth; flagellum about as long as the peduncle.

First maxillæ with the inner plate about $\frac{2}{3}$ the length of the outer and furnished with 2 plumose setæ; outer plate armed distally with 7 spine-teeth each of which is furnished with 1 or 2 small curved teeth near the middle; first joint of the palp about as wide as long, second joint elongated, armed distally with several slender spines and reaching considerably beyond the end of the outer plate but not to the tip of the spine-teeth. Inner plate of the second maxillæ shorter than the outer but of about the same width. Inner plates of the maxillipeds very small, oblong, the distal margin furnished with spines and setæ and reaching scarcely beyond the base of the outer plates; outer plates not reaching the middle of the large second joint of the palp; third joint of the palp pyriform; fourth joint a large, curved, acute claw nearly as long as the preceding joint.

First gnathopods with the third joint truncated below and somewhat produced at the postero-inferior angle; carpus produced posteriorly into an oblong, distally rounded process which is curved downwards; hand ovate, anterior and posterior margins evenly curved and equally convex; palm occupying about $\frac{3}{4}$ the posterior margin and terminated by a short spine; dactyl rather slender, evenly tapering to a sharp point. The second gnathopods very closely resemble the first but are somewhat larger, with the propodus and the posterior lobe of the carpus slightly more narrow. First 2 pairs of pereiopods rather short, the dactyls $\frac{1}{2}$ the length of the propodi; the 2 following pairs longer with the dactyls slightly longer than the propodi; posterior pair of pereiopods large, elongated, nearly twice the length of the preceding pair and reaching beyond the tip of the uropods.

Peduncles of the uropods prismatic in section with prominent angles; peduncle of the first pair reaching to about ⅔ the length of the peduncle of the second pair, rami acicular, somewhat flattened, shorter than the peduncle, the inner ramus broader and slightly longer than the outer; peduncle of the second pair of uropods reaching the extremity of that of the third pair; peduncle and rami of the third pair of subequal length. All the uropods are nearly alike in character and the tips of the rami extend to about the same distance posteriorly, those of the second pair slightly exceeding those of the first and third; the margins of the rami are armed with numerous minute spines. Telson oblong, a little longer than the upper portions of the 2 last abdominal segments, raised along the mid-dorsal line, broadly emarginate at the tip, and rounded at the postero-lateral angles.

Length 35 mm.

Described from Mr. Lockington's four type specimens which came from the "west coast of Alaska, north of Behring's Straits" (No. 3561, collection of the California Academy of Sciences).

This species is allied to *A. Malmgreni* (Goës) but differs in having a more strongly curved rostrum, in having the postero-lateral angles of the anterior abdominal segments flattened or broadly rounded, instead of produced into spines, and in having no tooth near the middle of the palm of the gnathopods. The general shape of the hands in the two species is also very different. It is probable that Stuxberg confused this species with *Malmgreni* as his figure, which is copied by Della Valle to illustrate the latter species, agrees closely with Miers' figure of *pulchra* and differs markedly from the original figure of *Malmgreni* given by Goës.

Family EUSIRIDÆ.

### Rhachotropis aculeata *(Lepechin).*

*Oniscus aculeatus* Lepechin, Acta Acad. Sci. Imp. Petrop. 1780, p. 247, tab. VIII, fig. 1.

*Rhachotropis aculeata* Smith, Proc. U. S. Nat. Mus. v. 6, pp. 222, 229, 1884. Stebbing, Challenger Reports, v. 29, p. 954, 1888.

*Pontogeneia aculeata* Della Valle, Fauna und Flora des Golfes von Neapel, 20 Monogr. p. 616, tav. LIX, fig. 28, 1893.

A single specimen of this species was found in the bottle containing Lockington's types of *Oediceros behringiensis*. For further references and synonyms see Stebbing, *l. c.*, or the monograph of Della Valle.

## Suborder ISOPODA.

### Family LIGIIDÆ.

### Styloniscus gracilis *Dana*.

PLATE XXXVI, FIGS. 29–31.

*Styloniscus gracilis* Dana, Proc. Acad. Nat. Sci. Phila. v. 7, p. 176, 1854. Stimpson, Jour. Bost. Soc. Nat. Hist. v. 7, p. 506, 1857. Stuxberg, Öfversigt af k. Vetensk. Akad. Förhandl. 1875, N:o 2, p. 43. Budde-Lund, Crust. Isop. Terrestria, p. 271, 1885. Richardson, Proc. U. S. Nat. Mus. v. 21, p. 867, 1899.

*Alloniscus maculosus* Harford, Proc. Calif. Acad. Sci. v. 7, p. 54, 1877.

Thoracic segments smooth, glossy, and of subequal length; postero-lateral and antero-lateral angles of the first 4 rounded, the postero-lateral angles of the last 3 segments acute and produced backwards.

Abdomen longer than wide, abruptly narrower than the thorax, the first 2 segments shorter than the others, the 3 following segments with the postero-lateral angles acute and produced backwards. Terminal segment twice as wide as long and very broadly rounded.

Head transverse, devoid of prominences, front broadly rounded. Eyes rather large reaching the lateral margins of the head. Antennules three-jointed, not exceeding the second basal joint of the antennæ; first joint broad, distally widened; second joint subcylindrical, slightly longer and much narrower than the first; third joint very minute and joined to one corner of the preceding. Antennæ nearly ½ the length of the body, first joint short, transverse, second and third joints oblong, cylindrical, subequal, fourth joint as long as the 3 preceding, fifth joint narrower and slightly longer than the fourth; flagellum about as long as the 2 preceding joints and composed of 13–15 articulations.

Mandibles short and very stout, having a large molar tubercle and a narrow dark-colored, dentate cutting edge, but no palp. First maxillæ with the inner plate short and furnished with 3 short-ciliated setæ, the upper 1 much shorter than the lower 2 which are of subequal length; outer plate narrow and armed with 5 curved teeth. Second maxillæ narrow, with 2 very small ciliated plates on the inner margin near the rounded tip. Inner plate of the maxillipeds with several short, densely ciliated processes on the transverse distal margin and a large ciliated seta on the inner side; palp five-jointed, the terminal joint minute.

Legs very spiny below; dactyls short, furnished with several setæ and 1 or 2 spines below near the tip. Uropods slender, fully ½ the length of the abdomen; peduncle oblong, flattened, the inner angle strongly produced backwards; rami slender, microscopically scabrous but devoid of spines; inner ramus exceeding the outer in length but slightly more slender, the tip furnished with setæ.

The body is furnished with scattered fine short hairs which are more conspicuous on the posterior margins of the segments.

Length $\frac{7}{10}$ inch.

Described from three type specimens of Mr. Harford's *Alloniscus maculosus* (No. 2594) from Angel Island, Bay of San Francisco.

## Family CIROLANIDÆ.

### Cirolana Harfordi *(Lockington).*

PLATE XXXVII, FIGS. 32–38.

*Ægа Harfordi* Lockington, Proc. Calif. Acad. Sci. v. 7, p. 46, 1877.
*Cirolana californica* Hansen, Vidensk. Selsk. Skr. ser. 6, Natur. og math. Afd. 5, 1890, pp. 338, 339 (fide Richardson).
*Cirolana Harfordi* Richardson, Proc. U. S. Nat. Mus. v. 21, p. 822, 1899.

Body nearly smooth. Sides of the thorax nearly parallel, the first segment marked longer than the subequal following ones, the antero-lateral angles produced forward as a triangular, acute or subacute process which commonly covers the lower part of the eye. Epimera oblong, the postero-lateral angles of the first 3 segments rounded, those of the last 4 acute and produced backwards. The epimeral suture on the first segment is much less distinct than in the others and extends upwards and forwards to the upper corner of the head. The lower margins of the epimera are bordered by a broad raised line which is wider in front than behind and which becomes successively wider in front in the posterior segments until it includes the larger portion of the epimera.

Abdomen short, the first segment concealed by the thorax, the 3 following ones of equal length, and concave behind; fifth segment longer in the middle and shorter at the sides than the preceding ones, the posterior margin nearly straight (usually a little convex); postero-lateral angles of the first 2 segments acute but commonly concealed by the epimeron of the last thoracic segment; postero-lateral angle of the third segment subacute or narrowly rounded, that of the fourth produced and rounded; lateral angle of the fifth segment subacute but concealed by that of the preceding segment. Telson equilaterally triangular, a little longer than the preceding segments of the abdomen, the lateral margins concave near the bases of the uropods, but otherwise nearly straight; tip rounded and furnished with short spines which are longest near the center and extend only a short distance along the sides.

Head transverse, the front broadly and evenly rounded, the frontal margin raised; a transverse impressed line extending across the front part of the head from the upper sides of the eyes. Antennules reaching the posterior margin of the head, the peduncle reaching the anterior border of the eye and beyond the tip of the third joint of the antennæ but scarcely to the middle of the fourth; first joint rounded, about as wide as long; second joint a little longer than wide; third about as long as the first 2; flagellum about as long as the base and composed of 10-16 articulations. Antennæ about half the length of the body; fifth joint slightly longer than the fourth, and about equal in length to the first 3; flagellum nearly twice the length of the peduncle.

Mandibles with a rudimentary cutting edge and a flattened somewhat twisted lobe projecting inward from the lower side of the trunk and armed with several spines on the rounded margin; on the lower side of the mandible there is a large, flattened, lamellate process, the entire inner margin of which is closely set with spines; palp elongated, second joint about 1½ times the length of the first and setose on the distal ⅓ of the outer side; third joint about ⅔ the length of the second, the outer margin slightly concave and setose, the setæ becoming longer towards the distal end which is furnished with a few setæ of larger size. First maxillæ with the inner plate small and armed with 3 ciliated spines, outer plate with the distal margin very oblique and armed with 9 curved spine-teeth. Second maxillæ with the movable plates narrowly oblong and subequal; inner side of the basal plate nearly straight and setose. Maxillipeds with the inner plate narrow and pointed, about reaching the middle of the second joint of the large five-jointed palp and furnished with several plumose setæ, the inner margins armed with hooks.

Thoracic legs very spiny, the dactyls short with a short spine just behind the tip. Uropods with the rami of equal length and reaching the tip of the telson; end of the peduncle below the outer uropod with 3 or 4 spinules; inner angle of the peduncle prolonged into a large, narrow, sharp process reaching nearly to the rounded inner angle of the inner ramus; outer ramus narrowly oblong, much narrower than the inner, and rounded at the tip and armed with 4 or 5 spines among the setæ on the distal portion of the inner margin; inner ramus distally widened, the posterior angles rounded, the terminal margin oblique, setose, and armed with short spines.

Length .63 inch.

The ground color in the alcoholic specimens is a light yellow and the presence of small dark-colored spots in greater or less abundance gives rise to considerable variation in coloration. A constant mark in the specimens at hand (but not equally plain in all) is a row on either side of each thoracic segment of oblong light-colored spots lying closely side by side. There is a space devoid of these spots along the middle of the back between the upper ends of the rows.

Six of the eighteen specimens of Mr. Lockington may be distinguished from the others by the presence of a pair of minute tubercles on the upper side of the telson and the more or less granulated margins of the posterior abdominal segments. A careful comparison of the two groups of specimens was made to determine whether there were any other features by which they might be distinguished. It was found that the six specimens in which there were tuber-

cles on the telson were all males, while all of the twelve remaining specimens in which the telson was smooth above were females. Not the smallest difference could be detected between the two series of specimens aside from these two features which are doubtless dependent upon difference of sex.

This description and the figures accompanying it are taken from specimens from the California Academy of Sciences (No. 2601) which are most probably the types described by Mr. Lockington. The bottle of specimens is labeled "*Idotea Harfordi*, Santa Rosa Is. W. G. W. Harford." Mr. Lockington, for some reason, came to regard his *Ægа Harfordi* as an *Idotea* as shown by Miers' statement that "the *Ægа Harfordi* of Lockington is designated *Idotea Harfordi* in a MS. note of the author. . . . Specimens, however, are in the British Museum from Santa Rosa Island, received from Mr. Lockington, which do not belong to any genus of *Idoteidæ*, but to *Cirolana*, or a closely allied type" (Jour. Linnean Soc. v. 16, p. 19, 1883). The specimens sent to the British Museum and those here described are probably parts of the same lot.

## Family ASELLIDÆ.

### Asellus tomalensis *Harford.*

PLATE XXXVII, FIGS. 39-42.

*Asellus tomalensis* Harford, Proc. Calif. Acad. Sci. v. 7, p. 54, 1877. Richardson, Proc. U. S. Nat. Mus. v. 7, p. 856, 1899.

Body narrow in front, widening gradually posteriorly. Thoracic segments of about equal length, with the sides rounded, the first segment slightly longer than the others and having a notch in the lateral margins; anterior segments concave in front, posterior ones concave behind.

Head broader than long, widest a short distance behind the eyes; frontal margin concave, antero-lateral angles rounded. Eyes rather small. First antennæ about reaching the middle of the last joint of the peduncle of the second pair, the first joint oblong, flattened, outer margin concave, the inner convex, second joint subcylindrical, longer than the first but about half as wide; third joint narrower than the second and about ⅓ as long; flagellum nearly as long as the peduncle and composed of 10 joints. Second antennæ

about half the length of the body; first joint of the peduncle with a subquadrate external lobe; fourth joint about $\frac{2}{3}$ the length of the fifth; flagellum considerably longer than the peduncle.

Mandibles with a large, elongated molar tubercle; palp three-jointed, the second joint longer than the first, widest near the middle and setose on the distal half of one side; third joint shorter than the second, arcuate and tapering to a point furnished with a few long setæ, the concave side thickly setose. Inner plate of the first maxillæ with 5 ciliated setæ at the distal end; outer plate with about 12 curved, denticulated teeth. Second maxillæ oblong, the inner plate with the distal margin ciliated and very oblique; outer plates reaching to the distal margin of the inner, their transverse distal margins furnished with long setæ. Maxillipeds with 7 or 8 blunt hooks on the inner margin of the inner plate.

First pereiopods with the first joint broad, the posterior margin more convex than the anterior; second joint longer than wide, third joint with an anterior pointed lobe, fourth joint very small and triangular; hand oblong, both margins about equally convex, the lower armed with stout spines; dactyl large, closing against nearly the whole length of the palm, the inner margin furnished with obliquely set spines which become larger toward the tip. Second pereiopods longer than the first, the first joint convex on both margins and twice as long as wide; second joint about as long as the fourth and strongly convex in front; third joint subtriangular, produced downward at the antero-distal angle; fourth joint armed below with 9 spines; fifth joint shorter than the fourth and armed below with 4 strong spines and a smaller fifth spine near the proximal end, the distal end produced into a pointed lobe beside the dactyl; dactyl armed below with 4 spines which increase in size toward the slender tip. Third and fourth pereiopods similar to the second. The last 3 pairs of pereiopods are longer and relatively more slender than the first pair and have the fifth joint as long as the fourth.

First pair of pleopods very small and oblong; second pair not fused in the middle, and forming an operculum over the succeeding ones. Caudal stylets but slightly longer than the abdomen, the peduncle oblong, flattened, armed with 5 spines on the inner and 4 on the outer margin; inner angle produced; outer ramus slender, spinulous, longer than the peduncle and setose at the tip.

The body is covered with short setæ which become longer on the margins.

Length $\frac{6}{10}$ inch.

This description is taken from the single type specimen of Mr. Harford (No. 2609, collection of the California Academy of Sciences). One of the caudal stylets was missing and in the other the inner ramus is much shorter than the outer. This is doubtless due to its having been lost and only partially regenerated. Its stump-like appearance would suggest this explanation; besides in several other specimens that I refer to this species the inner ramus is the longer of the two.

In several specimens from Point Arena, California, the caudal stylets are shorter than the abdomen. This is probably due to the fact that the individuals were not full grown, as they were all of smaller size than the type, and a careful comparison of mouth parts and other structures revealed no other important differences. A larger specimen taken from a well in Humboldt County, California, had the caudal stylets as long as those of the type.

All the specimens examined (which had been in alcohol for a long time) were of a grayish color, the segments of the thorax being marked with rounded or oblong spots of a lighter color.

I have compared the type and several other specimens of this species with specimens of *Asellus communis* Say from Massachusetts, Michigan, and Illinois. The two species are closely allied, but may be readily distinguished by the fact that the epimera in *tomalensis* are covered by the thoracic segments while in *communis* considerable portions of them are visible from above.

The form recently described as *Asellus tomalensis* by Miss Richardson is quite different from this species, as I have determined by a re-examination of Mr. Harford's type. Miss Richardson's species is much more slender, the antennæ longer, and the posterior segments of the thorax notched instead of rounded.

## Family SPHÆROMIDÆ.

### Sphæroma pentodon *Richardson.*

PLATE XXXVII, FIG. 43.

Head with the anterior margin bordered by a prominent raised line; median frontal process small and rounded; a conspicuous groove on either side in front of the eye into which the uropods are received when the animal is rolled up; the distance between the anterior ends of the grooves is slightly more than ½ the length of the anterior margin of the head. Epistome triangular, the lateral margins sinuated, the lower margin deeply concave, the acute apex in contact with the median process of the front. Eyes rather large, oval. Antennules reaching about to the posterior margin of the head; first joint flattened and rugose anteriorly, with a small lobe at the superoproximal angle which fits into an emargination on either side of the median

frontal process; flagellum about as long as the peduncle, and composed of 8–11 joints. Antennæ reaching about to the postero-inferior angle of the second thoracic segment; last 2 joints of the peduncle subequal; flagellum longer than the peduncle and composed of 12–15 joints.

Thoracic segments of subequal length, each crossed by a transverse ridge which becomes fainter to obsolescence on the anterior segments; postero-lateral angles of the segments produced backwards, those of the first 4 segments subacute, those of the last 3 becoming successively more rounded posteriorly. Anterior segment of the pleon crossed anteriorly by a faint line, and marked by 2 lines on either side which do not reach the middle of the dorsal surface; a transverse, roughened line across the middle portion of the segment. Caudal shield strongly convex, broadly rounded behind, roughened with small granulations and marked with a double longitudinal row of small tubercles which extend a little behind the middle of the dorsal surface; a transverse tubercle at the posterior end giving the segment, when viewed laterally, the appearance of being turned up at the tip. Rami of the caudal lamellæ subequal, acute, and scarcely reaching beyond the tip of the caudal shield; outer ramus armed with 4 or 5 sharp teeth (including the terminal one) on the distal portion of the outer margin; inner ramus devoid of teeth and fitting closely over the outer one.

Color olivaceous.

Length 9 mm.

Found in marshy ground in San Francisco Bay, California.

This species is quite different from *S. oregonensis* Dana; the body is more convex, the head not so much set back into the first thoracic segment, the caudal shield much longer and much less flattened. In *oregonensis* the caudal shield is perfectly smooth above and the outer ramus of the uropods is devoid of teeth. In the character of the outer uropods and several other features it resembles *S. quadridentatum* Say of the Atlantic coast, but the thorax is narrower, the epimera less distinct, the eyes larger and the uropods shorter and more acute.

UNIVERSITY OF MICHIGAN,
ANN ARBOR, MICHIGAN.

## [illegible]

The outlines of all the figures were traced by means of a camera lucida.

Fig. [illegible] [illegible]

Fig. 1. [illegible]

Fig. 2. [illegible]

Fig. 3. [illegible]

Fig. 4. [illegible]

Fig. 5. [illegible]

Fig. [illegible] [illegible]

Fig. 6. [illegible]

Fig. 7. [illegible]

Fig. 8. [illegible]

Fig. 9. [illegible]

Fig. 10. [illegible]

Fig. 11. [illegible]

Fig. 12. [illegible]

Fig. 13. [illegible]

Fig. [illegible] [illegible]

Fig. 14. [illegible]

Fig. 15. [illegible]

Fig. 16. [illegible]

Fig. [illegible] [illegible]

Fig. 17. [illegible]

Fig. 18. [illegible]

Fig. 19. [illegible]

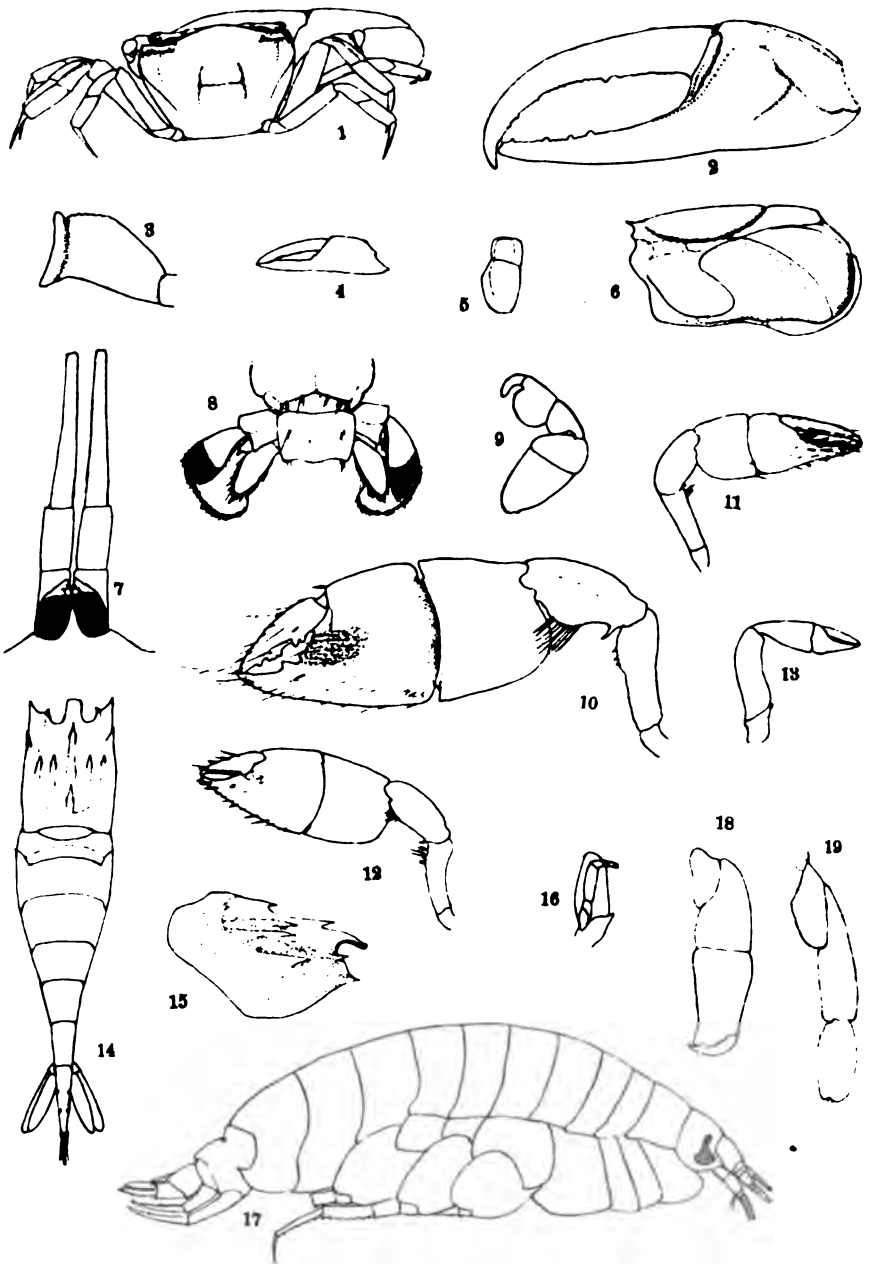



PHOTO LITH. BRITTON & REY, S.F.

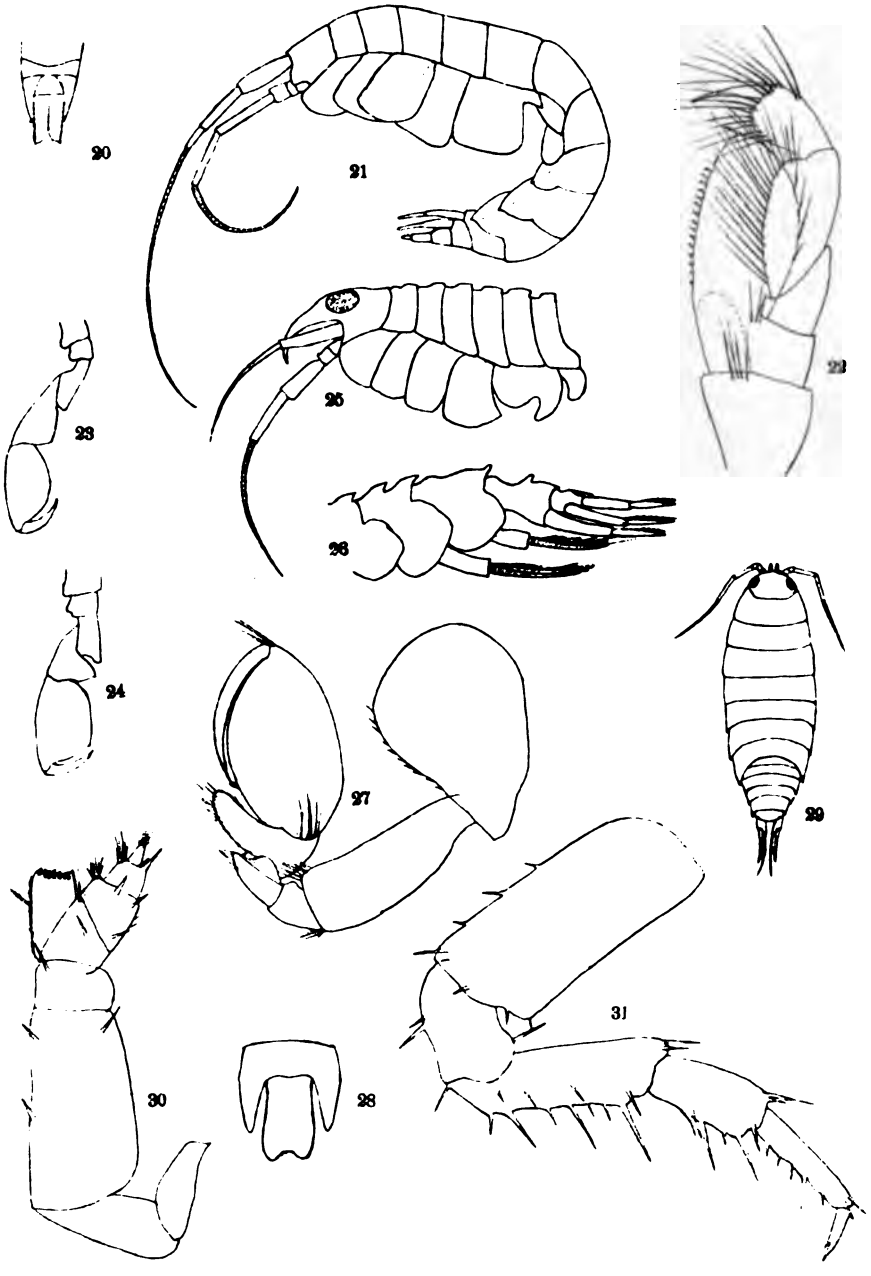
## EXPLANATION OF PLATE XXXVI.

Fig. 20. *Anonyx nugax.*
Fig. 20. Terminal portion of abdomen, seen from above.

Figs. 21–24. *Amphithoë scitula.*
Fig. 21. Outline of body.
Fig. 22. Maxilliped. Some of the spines near the tip of the outer plate have been broken off.
Fig. 23. First gnathopod.
Fig. 24. Second gnathopod.

Figs. 25–28. *Acanthostepheia behringanus.*
Fig. 25. Anterior portion of body.
Fig. 26. Abdomen.
Fig. 27. First gnathopod.
Fig. 28. Telson and sixth abdominal segment, seen from above.

Figs. 29–31. *Styloniscus gracilis.*
Fig. 29. Outline of body.
Fig. 30. Maxilliped.
Fig. 31. First pereiopod.

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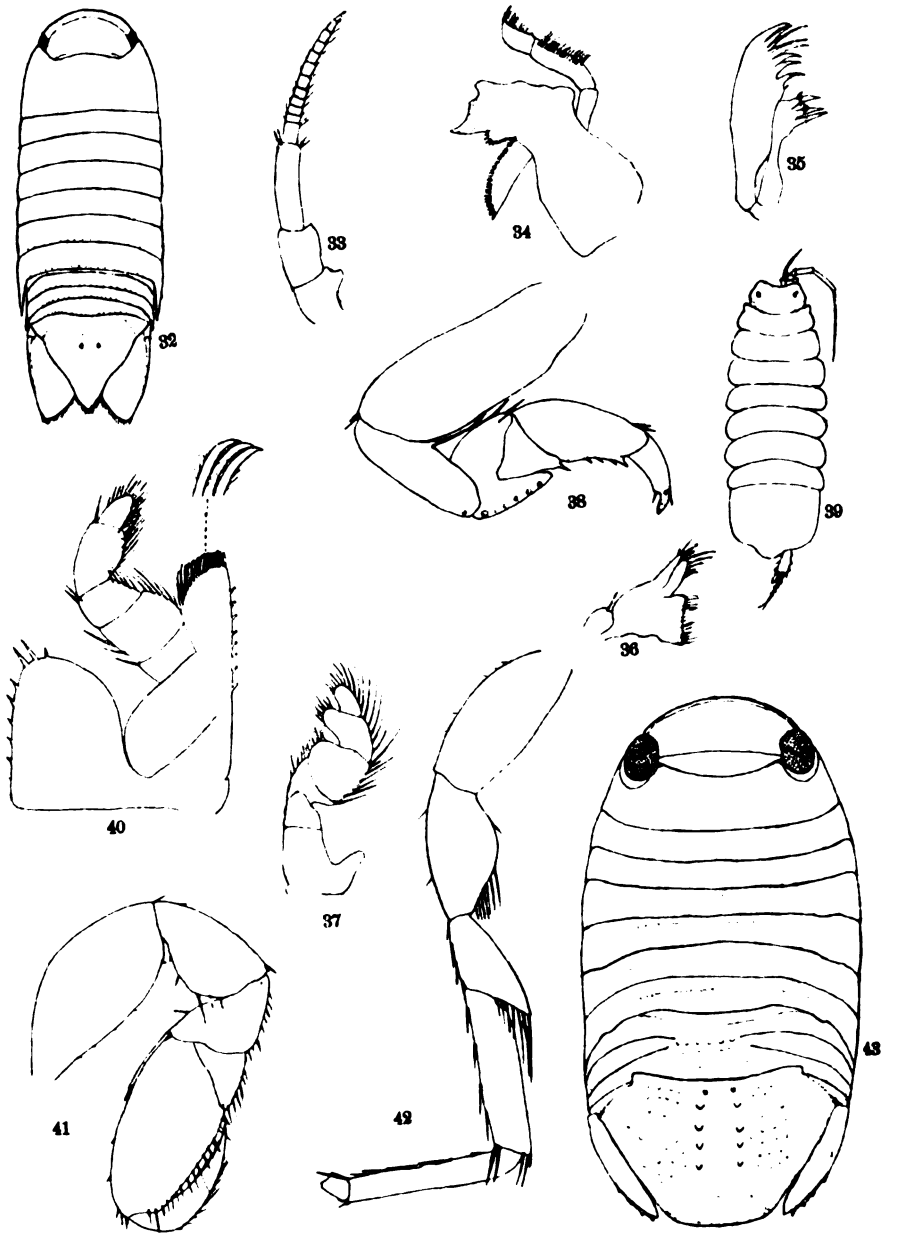
## EXPLANATION OF PLATE XXXVII.

Figs. 32–38. *Cirolana Harfordi.*
- Fig. 32. Outline of body.
- Fig. 33. Antennule.
- Fig. 34. Mandible.
- Fig. 35. First maxilla.
- Fig. 36. Second maxilla.
- Fig. 37. Maxilliped.
- Fig. 38. First pereiopod. The spines have been broken off from the under side of the third joint.

Figs. 39–42. *Asellus tomalensis.*
- Fig. 39. Outline of body.
- Fig. 40. Maxilliped.
- Fig. 41. First pereiopod.
- Fig. 42. Last pereiopod. A part of the dactyl has been broken off.

Fig. 43. *Sphæroma pentodon.*

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# Some Arachnida from California

BY

NATHAN BANKS

WITH FOUR PLATES

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# SOME ARACHNIDA FROM CALIFORNIA.

BY NATHAN BANKS.

PLATES XXXVIII-XLI.

THE following pages include a list of spiders and other Arachnida sent me for determination by the California Academy of Sciences, together with other Californian material received from several collectors.

The arachnid fauna of California is undoubtedly very large, so that this list is far from complete; yet it is full enough to show some of the more striking peculiarities of the fauna. The abundance of Pseudoscorpions and Phalangidæ is not equaled elsewhere in the country. There is a larger proportion of Thomisidæ and Drassidæ than is found in the eastern parts of the country. In Southern California there are a few species of a tropical aspect. In the northern parts, particularly from Mount Shasta, there are various spiders common to the northern parts of this country and of Europe. It is a notable fact that these northern spiders extend farther southward in California than they do in the Eastern States. Since Atlantic latitudes are colder than Pacific ones, it follows that these spiders flourish in California in a much warmer average temperature than they are accustomed to in the East.

Altogether there are two hundred and six Arachnida recorded in this list; one hundred and fifty-three spiders, and fifty-three of the other groups. The spiders belong to twenty-one families, eight of which are represented by but one species each. The largest family is the Attidæ with twenty-four species; then follows the Theridiidæ with twenty; the Epeiridæ and Thomisidæ each have eighteen. Of the other groups the Acarina and Phalangida have each nineteen species.

The types of the new species from the Academy's collection are in the Academy, the others are in the author's collection.

## ARANEIDA.

### THERAPHOSIDÆ.

**Bothriocyrtum californicum** *Cambridge.*

*Cteniza californica* Cambridge. Trap-door Spid. 2, 1874, p. 180.

One female from Southeast Farallon Islands, July (L. M. Loomis); others from Los Angeles (Davidson).

**Actinopus versicolor** *Simon.* Liste des espèces . . . Aviculariides, 1892, p. 14.

One female from Santa Clara County, July (Eisen); young from Sierra County, August (Fuchs); two from Black Mountain (Doane.)

**Hexura picea** *Simon.* Bull. Soc. Zool. France, 1884, p. 316.

One young specimen from Coulterville, Mariposa County, July (Eisen).

**Brachythele longitarsus** *Simon.* Ann. Soc. Ent. France, 1891, p. 305.

Several specimens from Fresno County (Clark); St. Helena, Napa County, July (Fuchs); Laundry Farm, Alameda County, July (Fuchs); San Francisco, June (Eisen).

**Atypoides riversi** *Cambridge.* Proc. Zool. Soc. London, 1883, p. 355.

Described from California. I have one from Black Mountain (Doane).

**Atypoides californica** *Banks.* Journ. N. Y. Ent. Soc. 1896, p. 88.

One specimen from Black Mountain, 23 October (Doane).

**Eurypelma californica** *Ausserer.* Verh. zool.-bot. Ges. Wien, 1871, p. 214.

*E. steindachneri* Ausserer. Ibid. 1875, p. 199.

Three specimens from Santa Cruz (M. Ankellie); one from Putnam Ridge, Fresno County (Clark); others from Claremont, October (Baker), and Los Angeles (Hutchinson).

## FILISTATIDÆ.

**Filistata hibernalis** *Hentz.* Spid. U. S. 1875, p. 24.

One specimen from Mill Valley, Marin County, 30 July (Fuchs); also from Los Angeles (Davidson).

## PHOLCIDÆ.

**Pholcus phalangoides** *Fuessl.* Verz. d. Schweizer Insekten, 1775.

One female from Laundry Farm, Alameda County, May (Fuchs); others from Los Angeles (Davidson and Hutchinson).

**Physocyclus globosus** *Taczanowski.* Horae Soc. Ent. Ross. x, 1874, p. 105.

*Pholcus gibbosus Keyserling.* Verh. zool.-bot. Ges. Wien, 1877, p. 208.

From Laundry Farm, Alameda County, July (Fuchs).

## SCYTODIDÆ.

**Diguetia canites** *McCook.* Spid. U. S. II, 1892, p. 135.

Specimens from San Diego, and Los Angeles (Davidson).

## LEPTONETIDÆ.

**Leptoneta californica** n. sp.

PLATE XXXVIII, FIG. 11.

Length ♀ 2.5 mm.; femur 1, 2 mm. Cephalothorax and sternum red-brown, both with a black margin; eyes on black spots; mandibles, legs, and palpi yellow-brown; abdomen gray above, marked transversely with blackish

behind, venter blackish. Cephalothorax rather broad, highest at dorsal groove, sloping to eye-region; eyes six, two behind close together, elliptical, two in front just touching, and one each side touching the tip of the anterior one, the latter seen in front are elevated; palpi very long and slender; legs slender, the anterior femora slightly thicker toward base, the hind femora bowed, metatarsi much longer than tarsi, all clothed with fine hairs, a few long spines on hind tibiæ; abdomen high, globose, region of epigynum swollen; sternum as broad as long, truncate in front, sides rounded.

One specimen from Mt. Diablo, Contra Costa County, June (Fuchs).

This genus is separated from the other Leptonetids by the position of the eyes; this is the first species known in our country.

## DYSDERIDÆ.

**Segestria pacifica** *Banks*. Can. Entom. 1891, p. 209.

From Mt. Shasta, and from an oak-gall, Claremont.

## DRASSIDÆ.

**Pœcilochroa pacifica** *Banks*. Plate XXXIX, Fig. 14. Banks, Journ. N. Y. Ent. Soc. 1896, p. 89.

Two specimens from Downieville, Sierra County, August (Fuchs); Stanford University and Claremont (Baker).

**Pœcilochroa montana** *Emerton*. Trans. Conn. Acad. Sci. VIII, 1890, p. 11.

A pair from Claremont (Baker). The male has a transverse white band on abdomen (instead of the two spots); the femora are black, the rest of the legs very pale; the tibia of palpus has a heavy spur on the outside, narrowed toward tip, lying upon the edge of the tarsus.

### **Drassinella** n. gen.

Cephalothorax with short groove; eyes as in *Pœcilochroa*, except that the S. E. are not their diameter apart, the posterior row being straight and longer than front row, with the M. E. nearer to P. S. E. than to each other. Mandibles slightly geniculate, no large tooth below, only one or two small ones. Legs long and slender; tibiæ I and II with two rows, each of five

spines, below, the last its length before tip; three such pairs under these metatarsi, hind tibiæ with a median and apical pair below, none above; tarsi weakly scopulate; lip rather broader than long; spinnerets not very long.

## Drassinella modesta n. sp.

PLATE XXXIX, FIG. 33.

Cephalothorax, mandibles, and legs dull yellowish brown, the latter paler on tarsi; sternum pale yellow-brown, dark on margin; abdomen dark gray above, with black hair; venter gray. Cephalothorax rather short; P. M. E. oval, more than longest diameter apart, a little nearer to nearly equal P. S. E.; A. M. E. about diameter apart, not one-half so far from slightly larger A. S. E. Quadrangle of M. E. much broader behind than in front; S. E. separate by about one-half diameter, equal. Sternum broadest at coxæ II, pointed behind, and but little longer than broad. Under tibiæ I and II after the large spines, are several pairs of minute spines. Abdomen nearly twice as long as broad, truncate at base, pointed behind.

Length 3.8 mm.

Two specimens from Santa Catalina Island (Baker).

**Megamyrmecion californicum** *Simon*. Plate XL, Fig. 48.
Simon, Ann. Soc. Ent. France, 1893, p. 308.

Two specimens from San Francisco, May (Fuchs); one from Claremont (Baker).

## Gnaphosa californica n. sp.

PLATE XXXVIII, FIG. 10.

Cephalothorax yellow-brown, with two black marks forming the V at base of head, side margins narrowly black; mandibles and sternum reddish brown; legs pale yellowish brown, tarsi of anterior legs darker; abdomen black above and below. Cephalothorax rather elongate, but head broad in front; anterior eye-row procurved, the A. M. E. small, about one-half diameter apart, still closer to the very much larger A. S. E.; posterior eye-row strongly recurved, P. M. E. about diameter apart, almost twice as far from the much larger P. S. E., S. E. equal, P. M. E. scarcely oval, and rather larger than the A. M. E. Legs not very long, very hairy, under tibiæ I and II usually a median spine and a pair at tip, metatarsi I and II with 2-1 spines beneath, tibiæ II and IV without spines above; sternum moderately broad, pointed behind; abdomen rounded at base, not much depressed.

Length 8 to 9 mm.

Two specimens from Claremont (Baker).

## Zelotes femoralis n. sp.

PLATE XXXVIII, FIG. 1.

Cephalothorax and mandibles yellow-brown; legs paler on base, beyond middle darker; sternum pale reddish brown; abdomen uniform dark gray; all clothed with black hair. Cephalothorax quite narrow in front: P. M. E. oval, one-half diameter apart, and as close to slightly smaller P. S. E.; A. M. E. nearly as large as the P. M. E., a little more than one-half diameter apart, and closer to the slightly smaller A. S. E., quadrangle of M. E. wider behind than in front. Sternum broadest at coxæ II; lip long and slender. Legs rather short, femora I and II heavy, no spines under tibiæ I or II, one under metatarsi I and II; hind legs numerously spined, but none above on base of either tibia III or IV; scopulas on tarsi rather weak. Abdomen quite long, but little depressed, with a crest of longer hair on base.

Length 9 mm.

One female from Claremont (Baker).

## Zelotes maculata n. sp.

PLATE XL, FIG. 38.

Cephalothorax dull yellowish, darker in front, furrows blackish; mandibles almost red-brown; sternum yellowish, blackish on sides; legs pale dull yellowish; abdomen pale, nearly covered above with black marks, a basal median one, a large one each side of it, and a row of narrow chevrons behind; venter blackish; spinnerets pale. Cephalothorax rather slender, narrow in front; posterior eye-row but little longer than anterior, barely procurved, P. M. E. oval, less than one-half diameter apart, twice as far from equal P. S. E., A. M. E. about diameter apart, almost touching the scarcely larger A. S. E.; mandibles slightly porrect. Legs rather slender, no spines under tibiæ I and II, 1-2 under metatarsi I and II, 2-2-2 under tibiæ III and IV, but none above at base. Sternum not very broad, broadest at coxæ II, but little narrowed in front, pointed behind; abdomen slender, twice as long as broad; spinnerets rather long and slender.

Length 4.5 mm.

One male from Claremont (Baker).

## Zelotes pacifica n. sp.

PLATE XXXIX, FIG. 15.

Length ♂ 6.7 mm. Cephalothorax yellow-brown, with black lines on furrows. Posterior eye-row rather longer than anterior, procurved; P. M. E. oval, oblique, their hind ends quite close together; A. M. E. full as large, round, more than their diameter apart, much closer to A. S. E.; S. E. smaller. Mandibles red-brown, moderate, vertical. Sternum truncate at

base, broadest in the middle, and pointed behind. Legs rather long, pale yellowish, anterior tibiæ rather more reddish, all with long hairs, no spines under tibia or metatarsus I, one under metatarsus II near middle, hind pairs with many spines; I pair rather short, IV pair longest. The abdomen depressed, nearly twice as long as broad, truncate at base where there are many long hairs; blackish, with a black basal spear-mark, and each side of it a few pale dots, and behind are several pale chevrons. Venter blackish, with two submedian pale lines reaching spinnerets. Palpal organ moderately long, a long blunt projection from the tibia over the tarsus.

One specimen, Santa Rosa Island, July (Eisen).

### Herpyllus angustus n. sp.

PLATE XL, FIG. 43.

Cephalothorax rather bright yellowish brown, margin black, mandibles and sternum similar; legs rather paler, except the femora, especially the anterior pair, are much darker, all with long black hair; abdomen black above and below, above with fine white hair. Cephalothorax rather slender, head narrow; legs thick and stout, especially leg I, tibiæ I and II with one spine at tip beneath, metatarsi I and II with a pair near base, a spine at base of tibia III above, none on tibia IV above, but 2-2-2 below, about four very stout spines above on each femur, scopulas moderately dense; sternum slender, considerably narrowed in front, pointed behind; abdomen truncate at base with a dense crest of black hair, depressed, and about twice as long as broad; lower spinnerets very large and prominent; male palpi short. Posterior eye-row straight, longer than the front row, P. M. E. round, about diameter apart, and a little closer to the equal P. S. E.; anterior eye-row straight, A. M. E. close together, and almost touching the slightly larger A. S. E., S. E. more than diameter apart.

Length 6 mm.

One male from San Pedro (Cockerell).

**Herpyllus californicus** *Banks.* Journ. N. Y. Ent. Soc. 1904, p. 110.

Described from Lakeside, California.

**Herpyllus validus** *Banks.* Plate XXXIX, Figs. 25 and 29. Banks, Trans. Amer. Ent. Soc. XXIII, 1896, p. 62.

Described from Los Angeles; also seen from Claremont (Baker).

**Callilepis insularis** *Banks.* Can. Entom. 1900, p. 97.

Described from Guadeloupe Island, off California, June.

### Drassodes californica n. sp.

PLATE XXXVIII, FIG. 8; PLATE XXXIX, FIG. 28.

Length ♂ 9 mm.; tibia plus patella IV 5 mm. Cephalothorax, legs, and sternum dark yellowish brown, mandibles more reddish brown, abdomen brown above and below. Cephalothorax much narrowed in front; anterior eye-row nearly straight, A. M. E. large, less than their diameter apart, less than their radius from the slightly smaller A. S. E.; posterior eye-row longer, procurved, but the S. E. separated by about their diameter, P. M. E. small, fully their diameter apart, about twice their diameter from the slightly larger P. S. E.; M. E. form a quadrangle much higher than broad, and about equally wide in front and behind; mandibles rather small, vertical; sternum plainly longer than broad, broadest at coxæ II, pointed behind; legs quite long and slender, two pairs of spines under, and one at inner tip of tibiæ I and II, these metatarsi with one pair of spines under the base, rest with scopulas, hind legs more numerously spined, one spine above on hind tibiæ, 3-3 below; abdomen depressed, truncate at base, blunt-pointed behind, nearly twice as long as broad; body clothed with whitish hair above; male palpi short, the tibia with a short pointed process on the outer tip. A shield on base of male abdomen above.

Two males, Downieville, Sierra County, August (Fuchs); and Marin County (Vaslit).

## CLUBIONIDÆ.

### Gayenna californica n. sp.

PLATE XXXVIII, FIG. 2.

Length 5.5 mm. Cephalothorax yellowish, with two irregular brownish marks each side, eyes on black spots, those of the P. M. E. usually elongate behind, mandibles dark, legs and sternum pale yellowish, the former with dark spots at the bases of the spines, abdomen pale grayish, with red-brown spots above, the principal ones outlining a triangle at base, and behind are two converging lines of dots, smaller ones on the sides, venter mostly immaculate, but usually one prominent spot in the middle just basad of the furrow. Cephalothorax narrowed in front; P. M. E. about their diameter apart, closer to the equal P. S. E.; A. M. E. smaller; mandibles small, vertical; legs rather short and stout, two pairs of spines under tibiæ I and II, more on hind pairs; sternum plainly longer than broad, sides rounded, pointed behind; abdomen one and one-half times longer than broad, pointed behind, rounded at base; ventral furrow not reaching middle of venter; epigynum shows two reddish lines each side, and in front two dark oblong spots.

Several specimens, Mill Valley, Marin County, May (Fuchs); Palo Alto (Doane).

**Chiracanthium inclusa** *Hentz.* Spid. U. S. 1875, p. 85.

One specimen from Mill Valley, Marin County, May (Fuchs); also from Claremont (Baker).

**Clubiona pacifica** *Banks.* Trans. Amer. Ent. Soc. XXIII, 1896, p. 65.

One female from Mt. Shasta (Lembert).

**Anyphæna** sp.

Immature specimens from Palo Alto. Similar to *A. gracilis* Hentz. It is pale yellowish, with two narrow gray stripes on the cephalothorax and abdomen; mandibles and clypeus black.

**Micaria palliditarsus** *Banks.* Trans. Amer. Ent. Soc. XXIII, 1896, p. 59.

Described from Southern California.

**Castaneira crocata** *Hentz.* Spid. U. S. 1875, p. 93.

Two females from Claremont (Baker).

**Trachelas tranquilla** *Hentz.* Spid. U. S. 1875, p. 89.

One female from mountains near Claremont (Baker).

**Trachelas californica** n. sp.

PLATE XL, FIG. 47.

Cephalothorax uniform dull red-brown; scarcely roughened, the erect hairs upon tiny tubercles; dorsal groove very short. Mandibles scarcely paler than cephalothorax, slightly divergent. Posterior eye-row very plainly recurved; the P. M. E. one and one-half their diameter apart, and as far from the scarcely larger P. S. E., which are nearly their diameter from the smaller A. S. E.; A. M. E. about their diameter apart, closer to the slightly larger A. S. E.; quadrangle of M. E. higher than broad, and broader behind than in front. Legs with femora pale yellow, beyond more brownish yellow, tips of hind tibiæ and metatarsi nearly black; no spines, but many hairs, the anterior tibiæ, metatarsi, and tarsi quite densely black-haired beneath. Sternum yellow-brown, broadest at coxæ II. Abdomen rather depressed, truncate at base, pale brownish yellow above, a slender black basal spear-mark, two submedian black dots, and faint black marks on posterior sides, tending to form chevrons.

Length 5 mm.

One female from Claremont (Baker).

ZOROPSIDÆ.

**Lutica maculata** *Marx.* Proc. Ent. Soc. Wash. III, 1892, p. 33.

Two specimens, July (Eisen). A very interesting species, and the only representative of the family in this country.

AGALENIDÆ.

**Agalena pacifica** *Banks.* Journ. N. Y. Ent. Soc. 1896, p. 89.

*Agalena curta* McCook. Amer. Spid. II. [No description].

Specimens from Marin County (Vaslit); St. Helena, Napa County, July (Fuchs); Stanford University; Claremont and Santa Catalina Island (Baker).

**Agalena californica** *Banks.* Journ. N. Y. Ent. Soc. 1896, p. 89.

Described from Black Mountain (Doane); also seen from Stanford University, and Claremont, October (Baker).

**Tegenaria derhami** *Scopoli.* Entom. Carnioli, 1763, p. 400.

Specimens from San Francisco (Fuchs) and Santa Clara County (Baker).

**Tegenaria californica** *Banks.* Journ. N. Y. Ent. Soc. 1896, p. 90.

Mt. Diablo, Contra Costa County (Fuchs); Stanford University (Doane).

**Cybæus reticulatus** *Simon.* Ann. Soc. Ent. Belg. 1886, p. 56.

One from San Francisco, July (Fuchs).

## Cybæus minor n. sp.

PLATE XXXVIII, FIG. 4; PLATE XL, FIG. 44.

Cephalothorax, legs, and sternum yellowish brown, the anterior part of cephalothorax and the anterior legs beyond femora more reddish; mandibles reddish brown; abdomen black above, an indistinct median, basal pale line, and five pairs of submedian white spots, the posterior ones oblique and more or less connected; venter pale. Posterior eye-row faintly recurved, the P. M. E. a little more than diameter apart, and barely so far from the equal P. S. E.; A. M. E. much smaller than the other eyes, about diameter apart, and farther from the much larger A. S. E. Mandibles strongly geniculate at base, tibiæ I and II with 2-2 spines beneath, metatarsi I and II, with 2-2-2; tibia III with 2-2-2 beneath, metatarsus III with 2-2; tibia IV with 1-1-1.

Length ♂ 4.8 mm.; ♀ 5 mm.

A pair from Claremont (Baker).

**Chorizomma californica** *Simon.* Bull. Soc. Zool. France, 1895, p. 136.

Two specimens from San Francisco, September (Carlson).

**Cybæodes (?) incerta** *Banks.* Can. Entom. 1898, p. 185.

The type is from Salton, California, March (Hubbard).

### DICTYNIDÆ.

**Amaurobius nevadensis** *Simon.* Bull. Soc. Zool. France, IX, 1884, p. 12.

Several specimens, some from Marin County (Vaslit); Sierra County, August (Fuchs); Pine Ridge, Fresno County (Clark).

**Amaurobius pictus** *Simon.* Bull. Soc. Zool. France, IX, 1884, p. 13.

San Francisco (Troyer); Marin County (Vaslit).

**Dictyna sublata** *Hentz.* Spid. U. S. 1875, p. 147.

One from Lake Tahoe, Placer County, July (Troyer); one from Laundry Farm, Alameda County (Fuchs); Palo Alto, July (Doane); Claremont and Santa Clara County (Baker).

**Dictyna volucripes** *Keyserling*. Verh. zool.-bot. Ges. Wien, 1881, p. 286.

Specimens from Claremont and Palo Alto (Baker).

**Dictyna** sp.

One female from San Francisco (Fuchs), possibly new.

### Dictyna calcarata n. sp.

PLATE XL, FIG. 42.

Cephalothorax red-brown, clothed with pale hair; mandibles red-brown; legs pale yellowish, beneath with black marks near middle and apex of each joint, except tarsus and patella, the marks on hind tibiæ surround the joint; sternum yellowish; abdomen whitish, with a median black spot in basal third, and behind is a series of black spots each side approaching near tip. Cephalothorax broad, head high, narrow, and long; mandibles slender, concave in front, not bowed out; legs rather more slender than usual; abdomen oval; male palpus has an enormous spur from the upper part of the tibia, which is itself a short joint.

Length 2.5 mm.

One male from San Pedro (Cockerell).

### Dictynina n. gen.

Similar in all important respects to *Dictyna*, but with the cribellum distinctly divided on the middle line; no spines on the legs.

Type, *D. pallida*.

### Dictynina pallida n. sp.

PLATE XXXIX, FIG. 22.

Cephalothorax pale, with the sides red-brown, leaving a white margin; legs pale, clothed with black hair; sternum brown; abdomen whitish, with an oblong median area of black hair in basal part, but not reaching base, and behind is a row of three black spots each side, more or less connected; venter with a brown median stripe, and spinnerets brown. Cephalothorax rather narrow; anterior eye-row straight, A. M. E. about diameter apart, closer to the equal A. S. E.; posterior eye-row a little procurved, P. M. E. about one and one-half diameter apart, and about as far from the nearly

equal P. S. E.; quadrangle of M. E. as wide behind as long, and a little wider behind than in front; legs quite long, without spines, but with many long hairs; abdomen oblong elliptical.

Length 3.1 mm.

Two females from Mt. Shasta (Lembert).

### Dictyolathys californica n. sp.

PLATE XXXVIII, FIG. 7; PLATE XL, FIGS. 40 AND 46.

Cephalothorax pale yellow, black around eyes, a narrow triangular blackish spot over dorsal groove; mandibles pale; legs pale yellowish, tibiæ and metatarsi darker; sternum blackish; abdomen pale, above with broad connected black bands which occupy most of the surface, these leave two large pale spots each side on anterior part, and behind five pale bands, the apical ones reaching sides; the sides streaked with black, connected to black above; venter with a black stripe each side connected to black surrounding spinnerets, and a short median black stripe. Cephalothorax rather broad in front, clypeus very low; both eye-rows strongly procurved, the A. M. E. very small, about diameter apart, and three times as far from the very much larger A. S. E., which are equal to the other eyes; P. M. E. fully diameter apart, and about as far from the nearly equal P. S. E. Mandibles vertical, not divergent; sternum broad, broadest behind coxæ II, pointed behind; abdomen elliptical, slightly depressed. Body and legs with many fine hairs, no spines.

Length 1.5 mm.

One female from Palo Alto (Baker).

## THERIDIIDÆ.

**Theridium tepidariorum** *Koch.* Die Arachn. VIII, 1840, p. 75.

San Francisco, two specimens, August (Fuchs); Los Angeles (Davidson); Lakeside (Baker).

**Theridium placens** *Keyserling.* Spinn. Amer., Therid. (1) 1884, p. 71.

San Francisco, July (Fuchs); Lake Tahoe, Placer County, July (Troyer); Palo Alto, July (Baker); Mt. Shasta (Lembert).

**Theridium differens** *Emerton.* Trans. Conn. Acad. Sci. VI, 1882, p. 9.

Several from Palo Alto (Baker) and Mt. Shasta (Lambert).

**Theridion furibundum** Keyserling. Spinn. Amer., Therid. (1) 1884, p. 175.

From Santa Cruz Island, 23 July.

**Theridion californicum** n. sp.

Plate XXXIX, No. 31.

Length 2 [illegible] mm., this pile patella 1.18 mm. Cephalothorax, legs, sternum, and mandibles ochre; abdomen yellow above, with a large, oblong, brown spot reaching from base to near tip, and sometimes containing two yellow spots near the middle, venter pale. Posterior eye-row straight, equal in size, P. M. E. slightly more than their diameter apart, and about as far from the P. S. E., A. M. E. smaller and fully twice their diameter apart, close to the equal A. S. E., S. E. rather larger; mandibles moderately vertical; sternum triangular, rather longer than broad, broadest and truncate in front, truncate behind between the hind coxæ; legs long and slender, femur 1 much longer than the cephalothorax, more than twice as long as femur IV., tibia 1 shorter than metatarsus 1, all clothed with fine hairs and a few slender spines; abdomen plainly longer than broad, rather high and convex; epigynum shows a dark triangular area, with the angles truncate, and containing two darker roundish spots.

Two specimens, Mill Valley, Marin County, 30 May (Fuchs).

**Theridion sexpunctatum** Emerton. Trans. Conn. Acad. Sci. VII. 1882, p. 11.

One adult male from Mill Valley, Marin County, May (Fuchs). Not previously recorded from the West Coast, but I have specimens from Washington State.

**Latrodectes mactans** Fabr. Die Aradin. VIII. 1840. p. 115.

Several specimens from Marin County (Vaslit); Fresno County (Bellman); Santa Rosa Island (Eisen); Mill Valley, Marin County (Fuchs); Claremont; Lakeside; Santa Catalina Island (Baker); Los Angeles (Davidson).

## Dipœna pictipes n. sp.

Cephalothorax bright yellowish, margin black, eyes on black spot; mandibles reddish yellow; legs black and whitish; femora and patellæ I and II white above, black beneath, femur II with a pale line, tibiæ and metatarsi black, former narrowly pale above, tarsi whitish; femora III pale, with black stripe on each side; femora IV pale, with black stripe on posterior side; tibiæ III and IV pale above, black beneath, metatarsi black, tips of tibiæ and bases of metatarsi pale, tarsi pale. Sternum bright yellowish, with a narrow black margin; abdomen black above and below, spinnerets pale. Posterior eye-row straight or barely procurved, P. M. E. fully diameter apart, and plainly farther from the equal P. S. E.; anterior eye-row straight, A. M. E. larger than P. M. E., scarcely diameter apart, and rather closer to the smaller A. S. E.; S. E. contiguous. Clypeus higher than the eye-region; sternum broad, nearly as broad in front as long, sides rounded, blunt-pointed between hind coxæ; leg I longest; IV and II subequal; abdomen elliptical, one and one-half times longer than broad, not very high.

Length 2.1 mm.

One specimen from Claremont (Baker).

## Euryopis californica n. sp.

PLATE XXXIX, FIGS. 23 AND 36.

Cephalothorax yellow-brown, eyes on black spots; mandibles pale yellowish, legs pale, mottled with black, mostly above, but the femora are below near tip; the tibial marks are more or less connected above; sternum pale. Abdomen silvery white, with a dark triangular spot in middle of dorsum, black on its posterior angle, there is also a black mark on each side, near tip of the abdomen, scarcely visible from above; venter silvery.

Structure in general similar to that of *E. funebre*, but the markings of legs different, and the abdominal spot very much smaller.

Length 3.8 mm.

One female from Los Angeles (Davidson).

**Euryopis funebre** *Hentz.* Spid. U. S. 1875, p. 148.

San Francisco, one specimen (Troyer).

**Steatoda grandis** *Banks.* Proc. Acad. Nat. Sci. Phil. 1901, p. 578.

One female from Claremont (Baker).

**Lithyphantes tectus** *Keyserling.* Spinn. Amer., Therid. (I) 1884, p. 138.

A male from Mt. Shasta (Lembert); a female, probably of this species, from Palo Alto (Doane).

**Argyrodes jucundus** *Cambridge.* Proc. Zool. Soc. London, 1880, p. 326.

Several from Los Angeles (Davidson) and San Pedro (Cockerell).

**Linyphia arcuata** *Keyserling.* Spinn. Amer., Therid. (II) 1886, p. 74.

One example, San Francisco, July.

**Linyphia diana** *Keyserling.* Spinn. Amer., Therid. (II) 1886, p. 68.

A female from Palo Alto (Doane).

**Linyphia phrygiana** *Koch.* Die Arachn. III, 1836, p. 83.

Several specimens from Palo Alto (Doane).

**Linyphia rubrofasciata** *Keyserling.* Spinn. Amer., Therid. (II) 1886, p. 66.

One female from Mt. Shasta (Lembert).

**Bathyphantes pallidula** n. sp.

PLATE XL, FIG. 45.

Cephalothorax, sternum, and legs pale yellowish, mandibles scarcely darker, abdomen rather grayish white. Cephalothorax moderately slender; anterior eye-row straight, A. M. E. small, close together; more than two diameters from the very much larger A. S. E., S. E. touching, P. M. E. fully diameter apart, and as far from the equal P. S. E., quadrangle of M. E. very much broader behind than in front. Mandibles rather long, vertical, not divergent, with a small tooth in front below, fang-groove excavate as seen from in front. Legs slender, femur I one-fourth longer than the cephalothorax, tibia I longer than femur, metatarsus I as long as femur, tarsus two-thirds of the metatarsus. Sternum very broad, broadest in front, pointed between hind coxæ; abdomen subcylindric, pointed at tip; body and legs quite hairy. Male palpal organ very large and complicated, dark red-brown; the hook is elbowed in the middle.

Length 2.7 mm.

One male from Claremont (Baker).

## Lophocarenum fasciatum n. sp.

PLATE XXXIX, FIGS. 20, 21, AND 24.

Cephalothorax yellowish, side-margins black, eyes on black spots; legs pale on femora, beyond more yellow; mandibles and sternum yellowish; abdomen pale, with a broad basal black band, and behind six interrupted black bars, sides streaked with black; venter pale, with a broad black area back of lung-slits connected to the upper basal band, and a large black spot each side near base of spinnerets. Cephalothorax of male elevated just behind eyes, not very high, with a round hole each side. A. M. E. small, close together, P. M. E. large, their diameter apart, rather closer to the equal P. S. E. Mandibles without tooth in front; legs short, hairy; sternum broadly truncate between hind coxæ, broadest on front margin; abdomen short, no shield above. Male palpi have basal joints very heavy, a long, slender, curved tibial hook, and the bulb tipped with a spiral tube, making two and one-quarter turns.

Length 1 mm.

One male from Claremont (Baker).

## Erigone californica n. sp.

PLATE XXXVIII, FIG. 3.

Length ♂ 2.2, ♀ 2.7 mm. Cephalothorax blackish, legs pale yellowish, mandibles yellow-brown, sternum dark, abdomen blackish, or dark gray above and below. Head of male elevated, margins with several teeth, two large ones each side on posterior part, and several on anterior sides; eyes with P. M. E. rather closer to each other than to P. S. E., A. M. E. as large as P. M. E. and slightly closer together, less than their diameter apart; mandibles large, a hump on each side near base, a large tooth on lower edge and several small ones, on the outer edge are two large, curved teeth slightly below the middle, and above them is a row of smaller ones; maxillæ below with a large tooth on outer side; legs moderately long, hairy; abdomen with short fine hairs. Male palpi long, with numerous short teeth on femur, one on outer tip, a large one under middle of tibia, and a large projection below the tip, tarsus rather longer than the tibia, a spine on the base of the swelling. In the female there is only a trace of the teeth on the mandibles. Some males are larger, with larger spines and redder cephalothorax and mandibles.

Laundry Farm, Alameda County, May (Fuchs); Mill Valley, Marin County, May (Fuchs); Mariposa County, July (Eisen); Santa Rosa Island, 20 May; Claremont (Baker).

November 30, 1904.

ARGIOPIDÆ.

**Miagrus** (*Epeira*) *cambridgei* (Thor.). Spid. U. S. 1875, p. 138.

Point Clarement (Baker) and Palo Alto (Doane).

EPEIRIDÆ.

**Epeira angulata** (Clerck). Svensk. Spindl. 1757, p. 22.

St. Helena, Napa County, July (Fuchs); Calaveras Creek, Alameda County, June (Fuchs); Los Angeles (Davidson).

**Epeira gemma** *M'Cook.* Proc. Acad. Nat. Sci. Phil. 1888, p. 199.

Marin County (Vasey); Yreka, Siskiyou County, June (Fuchs); Lannigy Farm, Alameda County, April (Fuchs); St. Helena, Napa County, July (Fuchs); Downieville, Sierra County, August (Fuchs); Santa Rosa Island, July (Eisen); Los Angeles (Davidson); Claremont and Santa Clara County (Baker).

**Epeira patilla** *M'Cook.* Amer. Spid. III, 1894, p. 180.

[illegible] Proc. N. Y. Ent. Soc. 1896, p. 30.

Lannigy Farm, Alameda County, April (Fuchs); Mill Valley, Marin County, May (Fuchs); Sebastopol, Sonoma County (Fuchs); Stanford University and Claremont (Baker).

**Epeira pungens** *Hentz.* Svensk. Spindl. 1757, p. 38.

Lannigy Farm, Alameda County, April (Fuchs); Sierra County, August (Fuchs); Mill Valley, Marin County, 30 May (Fuchs); San Francisco (Fuchs).

**Epeira trifolium** *Hentz.* Spid. U. S. 1875, p. 110.

San Francisco, August (Fuchs); Downieville, Sierra County, August (Fuchs).

**Epeira labyrinthea** *Hentz.* Spid. U. S. 1875, p. 111.

Marin County (Vaslit); Santa Rosa Island, July (Eisen); Mill Valley, Marin County, 30 May (Fuchs); Los Angeles (Davidson), Palo Alto (Doane); Claremont (Baker).

**Epeira displicata** *Hentz.* Spid. U. S. 1875, p. 117.

Mill Valley, Marin County, May (Fuchs); Sebastopol, Sonoma County, July (Fuchs); Mt. Shasta (Lembert).

**Epeira oacensis** *Keyserling.* Sitzungsber. Isis, Dresden, 1863, p. 121.

Specimens from San Pedro (Cockerell); Palo Alto (Doane); Los Angeles (Davidson).

**Epeira conchlea** *McCook.* Proc. Acad. Nat. Sci. Phil. 1888, p. 199.

One female from Claremont (Baker).

**Zilla californica** *Banks.* Journ. N. Y. Ent. Soc. 1896, p. 90.

Laundry Farm, Alameda County, April (Fuchs); San Francisco (Fuchs); Mt. Diablo, Contra Costa County (Fuchs); San Pedro (Cockerell); Palo Alto (Doane); Santa Clara County and Claremont (Baker).

**Cyclosa conica** *Pallas.* Spicilog. Zoolog. 1, 1772, p. 48.

Laundry Farm, Alameda County, May (Fuchs); Mill Valley, Marin County, May (Fuchs); Los Angeles (Hutchinson).

**Cyclosa index** *Cambridge.* Biol. Centrali-Amer., Arach.-Aran. 1, p. 51.

Mt. Diablo, Contra Costa County (Fuchs); Sebastopol, Sonoma County (Fuchs); Laundry Farm, Alameda County (Fuchs).

**Cyrtophora californiensis** *Keyserling.* Verh. zool.-bot. Ges. Wien, 1884, p. 525.

*Epeira bucardia* McCook. Amer. Spid. III, 1894, p. 183.

One specimen from Mill Valley, Marin County, May (Fuchs); others from Palo Alto (Doane); Mt. Shasta (Lembert).

**Ordgarius cornigerus** *Hentz.* Spid. U. S. 1875, p. 123.

A few from Los Angeles (Hutchinson). Mr. Hutchinson has described the curious manner in which this species catches insects (Scient. Amer. v. 89, 1903, p. 172).

**Argiope aurantia** *Lucas.* Ann. Soc. Ent. France, 1833, p. 86.

*Epeira riparia* Hentz. Spid. U. S. 1875, p. 106.

Hollister, San Benito County (Ludwig); Downieville, Sierra County, August (Fuchs); Marin County (Vaslit).

**Argiope argentata** *Fabricius.* Entom. System. II, 1793, p. 414.

Specimens from Los Angeles (Davidson); San Pedro (Cockerell); Santa Rosa Island, July (Eisen).

**Argiope trifasciata** *Forskael.* Descript. animal. 1775, p. 86.

*A. transversa* Emerton. Trans. Conn. Acad. Sci. VI, 1882, p. 330.

San Francisco, June (Eisen); Marin County (Vaslit); St. Helena, Napa County (Fuchs); Los Angeles (Hutchinson).

**Leucauge hortorum** *Hentz.* Spid. U. S. 1875, p. 118.

A few specimens from Los Angeles (Hutchinson).

TETRAGNATHIDÆ.

**Tetragnatha extensa** *Linnæus.* Syst. Nat. ed. XI, p. 621.

Laundry Farm, Alameda County, April (Fuchs).

**Tetragnatha laboriosa** *Hentz.* Spid. U. S. 1875, p. 131.

Laundry Farm, Alameda County, April (Fuchs); St. Helena, Napa County, July (Fuchs); Downieville, Sierra County, August (Fuchs); Los Angeles (Davidson); Palo Alto (Doane); Mt. Shasta.

## ULOBORIDÆ.

### **Uloborus californicus** n. sp.

PLATE XXXIX, FIG. 35.

Length ♀ 4 mm., tibia plus patella 1, 2 mm. Cephalothorax dark brown or reddish, paler behind; leg 1, femora brown (or reddish), with a pale spot below beyond middle, patellæ dark, tibia dark, base narrowly pale, metatarsi pale, with apical half dark (reddish); leg II, pale, apex of femora, most of patellæ, apex of tibiæ and base and apex of metatarsus dark (or reddish); hind legs, femora dark (or reddish), with a pale ring beyond middle, patella dark, tibiæ with a pale ring at base and before middle, and a dark ring on middle and apex of metatarsus, and often a band on the tarsi; sternum dark; abdomen dark on sides, pale above, more or less marked with dark spots, venter paler than sides, with a dark mark before the spinners and a small yellowish spot each side of it. Of the usual shape, the abdominal humps are more prominent than in the northern specimens of *U. plumipes*, none of the specimens show any trace of a brush on anterior tibiæ, one small spine above on tibia 1 beyond the middle, Epigynum shows two pale processes, suddenly narrowed on the inner side, convex outward.

St. Helena, Napa County, July (Fuchs). Readily separated from the eastern species by the dark apical half of the anterior metatarsi.

## THOMISIDÆ.

**Xysticus californicus** *Keyserling.* Plate XXXIX, Fig. 27; Plate XL, Fig. 41. Keyserling, Spinn. Amer. 1, 1880, p. 37.

Coulterville, Mariposa County, July (Eisen); Downieville, Sierra County, August (Fuchs); Santa Rosa Island, July (Eisen); Los Angeles (Davidson); Claremont and Elsinore (Baker).

**Xysticus formosus** *Banks.* Proc. Acad. Nat. Sci. Phil. 1892, p. 56.

One female from Mt. Shasta (Lembert).

**Coriarachne brunneipes** *Banks.* Journ. N. Y. Ent. Soc. 1893, p. 133.

One male from Mt. Shasta (Lembert).

**Runcinia californica** *Banks*. Can. Entom. 1900, p. 99.

Specimens from Los Angeles (Davidson) and Claremont (Baker).

**Runcinia aleatoria** *Hentz*. Spid. U. S. 1875, p. 77.

Coulterville, Mariposa County, July (Eisen); San Francisco (Fuchs).

**Misumena vatia** *Clerk*. Svensk. Spindl. 1757, p. 128.

San Francisco, July (Fuchs).

**Misumena importuna** *Keyserling*. Verh. zool.-bot. Ges. Wien, 1881, p. 307.

Marin County (Vaslit); Mill Valley, Marin County, 30 May (Fuchs); Santa Clara County (Baker).

**Misumena californica** *Banks*. Journ. N. Y. Ent. Soc. 1896, p. 91.

Coulterville, Mariposa County, July (Eisen); Laundry Farm, Alameda County, June (Fuchs); Mill Valley, Marin County, June (Fuchs); Los Angeles (Davidson).

**Misumessus pictilis** *Banks*. Jour. N. Y. Ent. Soc. 1896, p. 91.

Described from Palo Alto.

**Misumessus pallidulus** *Banks*. Journ. N. Y. Ent. Soc. 1904, p. 112.

Described from San Francisco.

**Tmarus magniceps** *Keyserling*. Spinn. Amer., Later. 1880, p. 158.

From Los Angeles (Davidson). Described from California.

**Thanatus coloradensis** *Keyserling*. Spinn. Amer., Later. 1880, p. 206.

Specimens from Claremont, October (Baker); and Zebra, Madera County, September (Miss Lorenson).

**Tibellus duttoni** *Hentz.* Spid. U. S. 1875, p. 81.

One specimen from St. Helena, Napa County, July (Fuchs); others from Elsinore and Santa Clara County (Baker).

**Tibellus oblongus** *Walckenaer.* Faun. Paris, II, 1802, p. 228.

Several specimens from Palo Alto, September; Santa Clara County (Baker).

**Philodromus rufus** *Walckenaer.* Faun. franc. Arach. 1806, p. 91.

*P. pictus* Emerton. N. Eng. Thomisidæ, p. 373.

Several specimens from Coulterville, Mariposa County, July (Eisen), and Mill Valley, Marin County, May (Fuchs).

**Philodromus** sp.

Two specimens of a species not known to me from Downieville, Sierra County (Fuchs) and Laundry Farm, Alameda County (Fuchs).

**Philodromus californicus** *Keyserling.* Verh. zool.-bot. Ges. Wien, 1883, p. 676.

One female from Santa Clara County (Baker); decribed from the State.

### Philodromus mœstus n. sp.

PLATE XXXIX, FIGS. 26 AND 30.

Cephalothorax pale brownish on sides, and in front, leaving a broad median whitish area; mandibles pale; legs pale, darker on the tibiæ; sternum pale; abdomen pale reddish brown, an oblong whitish spot each side on base, and smaller, rather indistinct, spots behind, more or less connected in pairs; venter pale. Cephalothorax a trifle longer than broad; P. M. E. almost three diameters apart, hardly half so far from the equal P. S. E., A. M. E. smaller, two diameters apart, and as far from the larger A. S. E., the latter barely if any closer to P. M. E. than to P. S. E. Legs slender, tibiæ I and II with 2–2 spines beneath. Abdomen nearly twice as long as broad, depressed.

Length 3.2 mm.

One male from Santa Clara County (Baker).

## SPARASSIDÆ.

**Olios fasciculatus** *Simon.* Act. Soc. Linn. Bordeaux, 1880, p. 307.

*Olios abnormis* Keyserling. Verh. zool.-bot. Ges. Wien, 1882, p. 679.
*Sadala simonii* Cambridge. Biol. Centrali-Amer., Arach.-Aran. I. 1890, p. 65.

Specimens from Zebra, Madera County, September (Miss Lorenson); Los Angeles (Davidson); Claremont (Baker).

## LYCOSIDÆ.

**Lycosa pacifica** n. sp.

PLATE XXXVIII, FIG. 6.

Length ♂ 14 mm; tibia and patella IV, 8 mm.; ♀ 18–20 mm. long. Cephalothorax with a pale stripe in middle, scarcely wider on head, a broader brown stripe each side, a narrow pale one on each side, and the margin narrowly brown; sternum pale yellowish; legs pale, darker on tarsi and anterior metatarsus and on tips of hind tibiæ and metatarsi, some small dark elongate spots above on femora; abdomen with a broad pale stripe from base to tip, broadest at base and there containing a dark spear-mark, which is black on the sides, brown on the middle; outside of the pale there is a brown stripe each side; sides and venter pale. Four pairs of spines under tibiæ I and II, three pairs in female. Epigynum shows a dark spot each side and one behind. Some specimens show a dark stripe each side on venter, and the sternum has a dark mark each side united behind.

St. Helena, Napa County, July (Fuchs); Coulterville, Mariposa County, July (Eisen); Santa Rosa Island, July (Eisen); Claremont (Baker); Santa Cruz Island, 23 July.

**Lycosa brunneiventris** *Banks.* Journ. N. Y. Ent. Soc. 1894, p. 50.

Two females from Palo Alto and Claremont (Baker).

**Lycosa** sp.

One male from Mill Valley, Marin County, May (Fuchs). It is a small species related to *L. modesta* Thorell, with a pale dorsal stripe on the cephalothorax, and dorsum of abdomen pale, black on sides in front; legs dark. It is probably new.

**Lycosa** sp.

One female from San Francisco, June (Eisen). It is a small almost black species; quite probably new.

**Geolycosa** sp.

One specimen from Los Angeles not quite mature; it appears to differ from the two described species.

**Pardosa californica** *Keyserling.* Plate XXXVIII, Fig. 5. Keyserling, Verh. zool.-bot. Ges. Wien, 1887, p. 483.

Specimens from Marin County (Vaslit); Mt. Diablo, Contra Costa County (Fuchs); San Francisco (Fuchs); Palo Alto, July (Baker).

**Pardosa atromedia** n. sp.

PLATE XXXIX, FIG. 32.

Cephalothorax pale yellowish; eye-region black, an irregular broad band on each upper side, which indents the middle area before the groove; clypeus with white hair; mandibles pale reddish brown, with white and black hair; sternum black, with pale margins; legs pale yellowish, banded with black; a black spot above on coxæ, two on femora, one on patellæ, two bands on tibiæ, and metatarsi dark at base and tip and less distinctly in the middle of hind pairs, tarsi unmarked. Abdomen pale yellowish with many white hairs, a basal black band under the front, an oblong median black spot at basal third, and beyond are smaller spots more or less distinct; sides streaked with black; venter entirely pale. Cephalothorax rather short; eyes of first row subequal, the M. E. rather farther apart than from S. E., eyes of second row scarcely diameter apart, dorsal eyes a little smaller; legs slender, hind pair very long; tibiæ and metatarsi I and II with 2-2 spines beneath.

Length 7-9 mm.

A few specimens from Claremont and Southern California (Curtice).

**Pardosa sternalis** *Thorell.*

*Lycosa sternalis* Thorell. Colo. Aran. 1877, p. 504.

Several specimens from Lake Tahoe, Placer County, July (Troyer); St. Helena, Napa County, July (Fuchs); Mill Valley, Marin County, May (Fuchs.)

**Pardosa glacialis** *Thorell.*

*Lycosa glacialis* Thorell. Spiders from Greenland, 1872.
*Lycosa concinna* Thorell. Colo. Aran. 1877, p. 506.

One pair from Mill Valley, Marin County, 30 May (Fuchs); both specimens very dark colored; others from Mt. Shasta (Lembert).

**Sossippus californicus** *Simon.* Ann. Soc. Ent. Belg. 1898, p. 25.

Described from the State; I have specimens from Claremont (Baker).

**Trochosa cinerea** Fabricius.

*Aranea cinerea* Fabricius. Ent. Syst. II, 1793, p. 423.
*Lycosa lynx* Hahn. Die Arachn. II, 1836, p. 13.

One specimen from Redding, Shasta County, June (H. C. Behr); others from Elsinore (Baker) and Santa Rosa Island, July (Eisen).

**Trochosa parva** *Banks.* Journ. N. Y. Ent. Soc. 1894, p. 52.

Two specimens from St. Helena, Napa County (Fuchs); also from Santa Rosa Island, July (Eisen).

**Pirata californica** n. sp.

PLATE XXXIX, FIG. 13.

Length ♀ 5 mm. Cephalothorax yellowish, two brownish lines on front uniting at dorsal groove two broader stripes each side, dentate outwardly; and the side margin brown. Eyes on black spots; mandibles brown; sternum pale yellowish; legs rather brownish, a pale ring beyond middle of each femur, and one on middle of hind tibia. Abdomen brownish above, a pale basal spear-mark and some faint chevrons beyond; venter much paler. Two pairs of spines under tibia 1 and three pairs under metatarsus 1; sternum a little longer than broad, sides rounded; abdomen but little longer or broader than the cephalothorax.

One female, Coulterville, Mariposa County, July (Eisen).

OXYOPIDÆ.

**Peucetia viridans** *Hentz.* Spid. U. S. 1875, p. 46.

Los Angeles (Davidson).

**Oxyopes salticus** *Hentz.* Spid. U. S. 1875, p. 47.

Mill Valley, Marin County, May (Fuchs); Palo Alto, September (Doane); Santa Clara County (Baker).

**Oxyopes rufipes** *Banks.* Journ. N. Y. Ent. Soc. 1893, p. 133.

Specimens from Mt. Shasta (Lembert); Santa Clara County (Baker).

**Oxyopes acutus** *Banks.* Proc. Calif. Acad. Sci. 3d Ser. Zool. 1, 1898, p. 279.

Coulterville, Mariposa County, July (Eisen); St. Helena, Napa County, July (Fuchs); Mill Valley, Marin County, 30 May (Fuchs). This species has somewhat the appearance of certain species of *Oxyopcidon* from Mexico.

ATTIDÆ.

**Phidippus johnsoni** *Peckham.* Descript. Attidæ, 1883, p. 22.

Coulterville, Mariposa County, July (Eisen); Yreka, Siskiyou County, June (Fuchs); Santa Barbara (Fuchs); Los Angeles (Davidson); Palo Alto (Doane); Claremont (Baker).

**Phidippus opifex** *McCook.* Proc. Acad. Nat. Sci. Phil. 1878, p. 276.

Two specimens, San Francisco, June (Eisen); Mill Valley, Marin County (Eisen); Los Angeles (Davidson).

**Phidippus bicolor** *Keyserling.* Verh. zool.-bot. Ges. Wien, 1884, p. 496.

A pair from Claremont (Baker), a male from Santa Catalina Island (Baker), and a female from San Bernardino County (Dunn).

**Dendryphantes octavus** *Hentz.* Spid. U. S. 1875, p. 70.

Sierra County, August (Fuchs); Mill Valley, Marin County, 30 May (Fuchs).

**Dendryphantes vitis** *Cockerell.* The Entom. 1894, p. 207.

A few specimens from Claremont (Baker).

### Dendryphantes guttatus n. sp.

PLATE XLI, FIG. 51.

Length ♀ 8 mm; ♂ 5 mm. Cephalothorax dark brown, clothed with dark hair and white scales, most numerous on front part of eye-region; mandibles red-brown; palpi pale; legs pale, femora mostly dark, patellæ, tibiæ and metatarsi annulate with red-brown at tips; sternum black; abdomen whitish at base, and basal part of sides, above with a large dark spot; small in front near base, at posterior part connected with dark sides, scarcely bronzy, with two submedian rows of four or five white dots and a few on the posterior sides; venter dark brown, with a line of pale dots on each side. Cephalothorax of male dark brown as in female; mandibles red-brown; vertical; legs I and II dark except tarsi; legs III and IV dark, except base of tibia, metatarsus, and all of tarsus; abdomen dark brown, above with white scales most numerous in spots on posterior sides. First leg largest. Tibia of male palpus with a very small projection on outer side at tip, a short stout style, base of bulb much swollen.

Several specimens, Santa Rosa Island, July (Eisen).

**Dendryphantes æneolus** *Curtis.* Zoe, III, 1892, p. 332.

Several specimens from Palo Alto (Baker).

**Dendryphantes harfordi** *Peckham.* Trans. Wisc. Acad. Sci. VII, 1888, p. 51.

Described from California, as a *Pseudicius*, but it does not belong to that genus; Claremont (Baker).

**Thiodina retarius** *Hentz.* Spid. U. S. 1875, p. 161.

From Yreka, Siskiyou County, June (Fuchs); San Francisco (Fuchs); Los Angeles (Hutchinson); Claremont (Baker).

**Pellenes signatus** *Banks.* Can. Entom. 1900, p. 101.

A few specimens from Los Angeles (Davidson).

**Pellenes elegans** *Peckham.* Bull. Wisc. N. H. Soc. 1900, p. 220, 1901.

One male from San Pedro (Cockerell).

**Pellenes tarsalis** *Banks.* Journ. N. Y. Ent. Soc. 1904, p. 118.

One male from San Pedro (Cockerell).

**Pellenes californicus** *Banks.* Journ. N. Y. Ent. Soc. 1904, p. 117.

One male from San Diego.

## Pellenes pacifica n. sp.

PLATE XXXIX, FIG. 37.

Length ♂ 4 mm. Cephalothorax dark red-brown, with black hairs, a long black fringe over the first eye-row; clypeus snow-white, with white scale-like hairs and longer fine white hairs; palpi mottled; sternum pale, darker on the sides; legs reddish-brown on basal joints, much paler on apical joints; abdomen black, with black hairs, an oblong, oblique white spot on each side near the middle, and behind on the median line is a small white spot, followed by two still smaller ones; venter pale. Of the usual structure; first pair of legs not much stouter than the others; leg III a little longer than leg IV, the patella simple. The male palpus short, the palpal organ flat and broad, with two elevated humps when seen in side view, both of the black projections on the inner side and starting near base, curving upward.

One male from San Francisco, July (Fuchs), known by the general black color, simple patella, white clypeus, and shape of the male palpus.

## Pellenes speciosa n. sp.

PLATE XL, FIG. 39.

Cephalothorax black, sparsely clothed with white and gray hair, a dark gray tuft at each anterior corner, which overlaps the heavy cream-white crest of hair over the eyes, the latter surrounds the eyes of the first row, the narrow clypeus is snow-white; the base of mandibles scarlet, with two black spots, apex yellowish; sternum and coxæ yellowish, with long white hair; legs mostly brown, the metatarsi and tarsi yellowish, mostly clothed with appressed white and erect black hair; leg I, however, has a dense brush of long bright red hair under apex of femora, whole of patella, and base of tibia, this when leg is flexed projects out each side; the tibia is yellowish, and has a black stripe on each upper side, but without long hair, the metatarsi yellowish, the tarsi jet black on apical half, basal part yellowish; the male palpus has black and white hair, but the tarsus is outside clothed with long bright red hair; venter pale, with three black stripes; dorsum (partly broken) is black, and clothed with white scales on base, and two oblique white bands each side,

the last reaching toward spinnerets. The cephalothorax is rather long, the legs quite short, and patella III simple. A female is similar, with white clypeus; black abdomen, with a median white herring-bone stripe, and white along sides.

Length 5 mm.

One pair from Claremont (Baker).

### **Epiblemum palpalis** n. sp.

PLATE XXXIX, FIG. 31.

Cephalothorax iridescent golden or purplish, with some white scales, a broad white band just behind the dorsal eyes, side margins narrowly white, clypeus with a few white hairs; mandibles black, paler on tips; palpi wholly pale yellowish, clothed with white hair; legs dark on femora, on patella and tibia I beneath, and on patella, tibia, and metatarsus IV, rest of legs mostly pale, a pale stripe above on femora I and II; sternum dark. Abdomen black, with black and some yellowish scales; three transverse white bands, one basal, one before middle, and one toward tip, a narrow white band encircles the spinnerets; these middle bands are straight across and not oblique as in *E. scenicum;* venter dark, clothed with black and white hair. Structure in general similar to that of *E. scenicum*, but the cephalothorax is plainly longer than in that species.

Length 5 mm.

One female from Palo Alto (Baker).

### **Metacyrba similis** n. sp.

PLATE XXXVIII, FIG. 9.

In general this species is similar to *M. tæniola*, but the abdomen has two unbroken white stripes, instead of two rows of dots; the venter is pale. The cephalothorax is a trifle shorter and broader proportionately than in *M. tæniola;* the male palpus has a shorter and broader palpal organ, the two long tibial hooks very similar to *M. tæniola*, but with the addition of a smaller tubercle at their base; the bulb is broader, especially at base, than in the other species.

Length ♂ 5.5 mm.

One male from Los Angeles (Hutchinson.)

**Metacyrba tæniola** Hentz. Spid. U. S. 1875, p. 56.

One from Claremont (Baker).

**Marpissa melanognathus** *Lucas.* Hist. Nat. d'Iles Canar. II, 1839, p. 29.

Mt. Diablo, Contra Costa County (Fuchs); Sebastopol, Sonoma County (Fuchs).

**Marpissa californica** *Peckham.* Trans. Wisc. Acad. Sci. VII, 1888, p. 81.

Yreka, Siskiyou County, June (Fuchs); San Francisco, June (Eisen); Mill Valley, Marin County, May (Fuchs); Calaveras Creek, Alameda County, June (Fuchs).

**Epiblemum scenicum** *Clerk.* Svensk. Spindl. 1757, p. 117.

Santa Barbara Island (Fuchs).

**Attus dorsatus** *Banks.* Can. Entom. 1895, p. 97.

Described from Southern California.

**Sidusa morosa** *Peckham.* Trans. Wisc. Acad. Sci. VII, 1888, p. 71.

One female from Mt. Diablo, Contra Costa County, (Fuchs).

**Sassacus popenhœi** *Peckham.* Occ. Papers, Wisc. N. H. Soc. II, 1895, p. 177.

One specimen from St. Helena, Napa County, July (Fuchs).

## PHALANGIDA.

### PHALANGIDÆ.

**Liobunum exilipes** *Wood.* Comm. Essex Inst. 1869, p. 32.

Specimens from Claremont, October (Baker); Mt. Shasta (Lembert); Santa Rosa Island, July (Eisen).

**Liobunum bimaculatum** *Banks.* Can. Entom. 1893, p. 210.

A few specimens from San Diego.

**Leuronychus pacificus** *Banks.* Can. Entom. 1894, p. 162.

Mt. Shasta (Lembert).

**Mitopus californicus** *Banks.* Journ. N. Y. Ent. Soc. 1895, p. 66.

From Los Angeles (Davidson).

**Leptobunus californicus** *Banks.* Can. Entom. 1893, p. 210.

From Los Angeles (Davidson).

**Globipes spinulatus** *Banks.* Can. Entom. 1893, p. 208.

A few specimens from Southern California.

**Eurybunus spinosus** *Banks.* Journ. N. Y. Ent. Soc. 1895, p. 66.

From Los Angeles (Davidson).

**Eurybunus brunneus** *Banks.* Can. Entom. 1893, p. 209.

One specimen from Southern California.

**Protolophus tuberculatus** *Banks.* Plate xxxviii, Fig. 19. Banks, Can. Entom. 1893, p. 206.

Specimens from Mill Valley, Marin County, May (Fuchs); Santa Rosa Island, July (Eisen); Santa Catalina Island, Claremont, and Santa Clara County (Baker).

**Protolophus singularis** *Banks.* Can. Entom. 1893, p. 207.

One from Southern California (Marx).

## NEMASTOMATIDÆ.

**Taracus pallipes** *Banks.* Can. Entom. 1894, p. 161.

Two specimens from Mt. Shasta (Lembert).

**Taracus spinosus** *Banks.* Psyche, March 1894, p. 51.

One from Southern California.

**Phlegmacera** sp.

Immature specimen from Santa Clara County (Baker).

**Nemastoma modesta** *Banks.* Psyche, March 1894, p. 52.

Specimens from Mt. Shasta (Lembert); Santa Clara County and Claremont (Baker).

## TROGULIDÆ.

**Ortholasma rugosa** *Banks.* Plate XXXVIII, Fig. 16. Banks, Psyche, 1894, p. 12.

Laundry Farm, Alameda County, April (Fuchs), one specimen; others from Claremont (Baker).

**Dendrolasma mirabilis** *Banks.* Plate XXXVIII, Fig. 17. Banks, Psyche, 1894, p. 12.

Coulterville, Mariposa County, July (Eisen), one specimen.

## COSMETIDÆ.

**Cynorta bimaculata** *Banks.* Trans. Amer. Ent. Soc. XX, 1893, p. 150.

The type is from San Diego.

**Sitalces californica** *Banks.* Plate XXXVIII, Fig. 18. Banks, Trans. Amer. Ent. Soc. 1893, p. 151.

Mill Valley, Marin County, May (Fuchs), one specimen; Mt. Shasta (Lembert).

**Scotolemon californica** *Banks.* Journ. N. Y. Ent. Soc. 1900, p. 200.

Described from Alabaster Cave, Placer County.

## SOLPUGIDÆ.

**Eremobates californica** *Simon.* Class des Galéodes, 1879, p. 143 (Datames).

Downieville, Sierra County, August, (Fuchs); Laundry Farm, Alameda County, June (Fuchs); San Diego; Alameda County, August (Eisen); Sonoma County.

**Hemerotrecha californica** *Banks.* Entom. News, 1903, p. 79.

Taken by Dr. Harold Heath at Pacific Grove, running in the sunshine.

November 30, 1904.

## PSEUDOSCORPIONIDA.

### CHELIFERIDÆ.

**Chelifer cancroides** *Linnæus.* Syst. Nat. ed. XII, 1767, p. 1028.

Specimens from Lake Tahoe (Hubbard).

**Chelifer scabriculus** *Simon.* Ann. Ent. Soc. France, 1878, p. 154.

Specimens from Southern California (Curtice).

**Chelanops acuminatus** *Simon.* Ann. Soc. Ent. France, 1878, p. 155.

A few specimens from Los Angeles (Davdson).

**Chelanops validus** *Banks.* Journ. N. Y. Ent. Soc. 1895, p. 7.

From Lake Tahoe, July (Hubbard).

**Chelanops dorsalis** *Banks.* Journ. N. Y. Ent. Soc. 1895, p. 8.

Described from Lake Tahoe, July (Hubbard).

### OBISIIDÆ.

**Ideobisium threveneti** *Simon.* Ann. Soc. Ent. France, 1878, p. 156.

**Ideoroncus obscurus** *Banks.* Can. Entom. 1893, p. 67.

One specimen from Lake Tahoe (Hubbard).

**Obisium macilentum** *Simon.* Ann. Soc. Ent. France, 1878, p. 156.

One from Southern California (Curtice).

**Blothrus californicus** *Banks.* Can. Entom. 1891, p. 165.

From Southern California (Curtice).

## SCORPIONIDA.

**Uroctonus phaiodactylus** *Wood.* Journ. Acad. Nat. Sci. Phil. 1863, p. 372.

Specimens from Claremont, October (Baker); Cuyamaja Mountains, San Diego County (Fuchs); Santa Cruz Mountains (Badger).

**Uroctonus mordax** *Thorell.* Ann. Mag. Nat. Hist. (4), XVII, 1876, p. 11.

Specimens from Lakeside (Baker); Sausalito, Marin County; Alameda County; Fresno County; Santa Rosa Island; San Francisco and Sonoma (Troyer).

**Hadrurus hirsutus** *Wood.* Journ. Acad. Nat. Sci. Phil. V, 1863, p. 367.

From Indio, Salton, San Bernardino County, and Tulare.

**Vejovis punctipalpi** *Wood.* Journ. Acad. Nat. Sci. Phil. V, 1863, p. 369.

Several from San Bernardino County.

## ACARINA.

### RHYNCHOLOPHIDÆ.

### Rhyncholophus gracilipes n. sp.

PLATE XLI, FIG. 56.

Length 3 mm. Body oblong, almost twice as long as broad, slightly constricted at hind and middle legs, broadly rounded behind; clothed above with many short, almost clavate hairs, below these are simple, but fully as dense; on the legs they are simple. Dorsal groove short, not reaching far on body, enlarged at each end. Legs slender; leg I about as long as the body, its last joint swollen and about two-thirds as long as the preceding joint; leg IV longer than the body and extending much beyond it, the last joint is swollen and scarcely one-third as long as the preceding joint; this, the penultimate joint, has on its under surface many stiff bristles, and a half whorl of them at its tip. Palpus of moderate size; femur not greatly swollen, tibia short and swollen above, claw large and stout with a tooth on inner surface, thumb large, rather clavate; all with long scattered hairs.

Several specimens from Santa Rosa Island, July (Eisen).

## BDELLIDÆ.

**Bdella californica** n. sp.

PLATE XLI, FIG. 60.

Body white, legs and palpi pale yellowish brown beyond base. Body narrowed in front to beak; an eye each side on cephalothorax, four bristles above, a short pair in front, and a longer one each side beyond eye; abdomen with a few short hairs above; legs rather slender, IV pair much the longest. Basal joint of palpus more than one-half length of mandibles, second and third together not as long, the latter the longer of the two, apical joint as long as basal, slightly larger at tip than elsewhere, with two long bristles on tip, the larger one nearly as long as the joint, several shorter bristles near tip.

Length 1.1 mm. (except beak).

A few specimens from Claremont (Baker).

## EUPODIDÆ.

**Rhagidia pallida** *Banks.* Trans. Amer. Ent. Soc. XXI, 1894, p. 222.

Two specimens from Claremont (Baker.)

## TETRANYCHIDÆ.

**Tetranychus mytilaspidis** *Riley.* Hubbard's Orange Insects, 1885, p. 216.

Various parts of Southern California, on orange.

**Tetranychus sexmaculatus** *Riley.* Insect Life, II, p. 225.

Also on orange, San Diego, Los Angeles, etc.

**Tetranychoides californica** *Banks.* Journ. N. Y. Ent. Soc. 1904, p. 54.

On the under surfaces of orange leaves, Watsonville (Volck).

**Tenuipalpus californicus** *Banks.* Journ. N. Y. Ent. Soc. 1904, p. 55.

On orange peel, Redlands (Pease).

## ORIBATIDÆ.

### Liacarus modestus n. sp.

PLATE XLI, FIGS. 53 AND 59.

Body pale reddish brown, legs pale yellow. Cephalothorax with four ridges and four long bristles above, setæ very short, capitate, two short bristles in front; abdomen rather depressed, smooth (finely pitted under high power), dorsum with four rows of recurved bristles, about seven in a row; legs rather short; coxal plate in two parts, each part with a short sutural line to indicate coxæ, but the lines do not reach middle; three equal tarsal claws; the circular anal opening two and one-half times its diameter in front of the larger, elliptical anal opening.

Length .7 mm.

Many specimens from Los Angeles. Related to *L. unicolor* Banks, but differs therefrom in the much shorter setæ.

### Oribata californica n. sp.

PLATE XLI, FIG. 52.

Abdomen red-brown; basal joints of legs brown, rest yellowish brown; cephalothorax brown. Cephalothorax with a pair of curved bristles in front, seta a long, erect, simple bristle; abdomen high, globose, above with a submedian row each side of about seven or eight short, strongly-curved bristles; genital and anal apertures close together, the former the larger. Legs not very long, the joints greatly swollen in places; the tarsi long and slender, femora have several strongly-curved hairs, the hairs beyond are less curved; there is but one tarsal claw.

Length .85 mm.

One specimen from Mt. Shasta.

### Phthiracarus cryptopus n. sp.

PLATE XLI, FIG. 50.

Body brown, more yellowish at base of abdomen, smooth and shining; legs pale. Cephalothorax with six bristles above, the anterior pair shorter than the others. Abdomen large and high, about one-fourth longer than broad, with two rows of fine hairs each side above, about five hairs in each row; other shorter hairs on the lower margin; ventral region very narrow, acute behind, divided before middle by a transverse notch; setæ are simple erect rods, barely thicker toward tip and not half as long as bristles. Legs very short, and hairy.

Length 1 mm.

Several specimens from Claremont (Baker).

## GAMASIDÆ.

### Gamasus californicus n. sp.

PLATE XLI, FIGS. 54, 55, AND 58.

Body yellowish, legs paler. Body subpyriform, but contracted slightly twice before the middle, broadly rounded behind, with a rather prominent bristle in front, and dorsum quite thickly clothed with curved hairs. Legs with long hairs and bristles; leg I slender, tarsus I with caroncle and claws rather weak; leg II of male heavy, a spur under femur, and a long tooth under tibia, tibia IV with one long spine below. Male mandibles simple. Peritreme nearly straight till in front of coxæ II, where it bends down, and then runs nearly straight forward, slightly upcurved at tip; venter smooth.

Length ♀ .8 mm; ♂ .6 mm.

A few specimens, from Claremont (Baker).

### Lælaps pilosula n. sp.

PLATE XLI, FIG. 49.

Length 1.1 mm. Abdomen about twice as long as broad, narrowed at each end, rather broadly rounded in front, blunt pointed behind, broadest beyond middle. Dorsal scutum divided, the anterior part reaching nearly to middle of body, posterior portion semicircular and hardly reaching half way to tip of body. Soft parts of body with many fine hairs, hard parts with scattered, longer hairs, one each side on anterior scutum is much larger than the others; each scutum shows above, sometimes indistinctly a pair of small circular impressions. Venter shows no hard parts; but in front is the curved genital opening, and each side is an oblique dark mark. The legs are short, the first pair about as long as body, with no claws at tip. The epistoma is broad, and pointed in the middle. The peritreme is just behind the third legs, and shows a double line extending forward and upward.

A few specimens, Santa Rosa Island, July (Eisen).

## IXODIDÆ.

**Argas miniata** *Koch*. Arch. f. Naturgesch. x, (1), 1844, p. 219.

Specimens from Lakeside (Baker).

**Ornithodoros megnini** *Dugès*. La Naturaleza Mexicana, VI, 1883, p. 196.

From Mt. Shasta, and Southern California (Curtice).

**Dermacentor reticulatus** *Fabricius.* Ent. Syst. IV, 1794, p. 428.

From Palo Alto (Baker) and Mt. Shasta (Lembert).

**Hæmaphysalis concinna** *Koch.* Arch. f. Naturgesch. x, 1844, p. 237.

From Claremont, on *Lophortyx californicus valloti* (Baker).

**Ixodes angustus** *Neumann.* Mém. Soc. Zool. France, 1899, p. 136.

Two from Siskiyou County, also received from Massett, British Columbia.

### Ixodes californicus n. sp.

PLATE XLI, FIG. 57.

Shield reddish brown, paler in the middle, body brown, or yellowish brown; coxæ brown, rest of legs paler. Body sparsely clothed with white hairs. Shield longer than in *I. hexagonus*, yet not nearly as long as in *I. frontalis*, finely punctured; body of female oblong-elliptical. Coxæ I with a black hump behind toward tip, but no basal spine, coxæ II and III with a prominent subapical spine behind, coxæ IV with a small protuberance; tarsi I with two little humps above near Haller's organ.

Length ♀ 4 mm.

Several specimens from *Toxostoma crissalis*, Claremont (Baker).

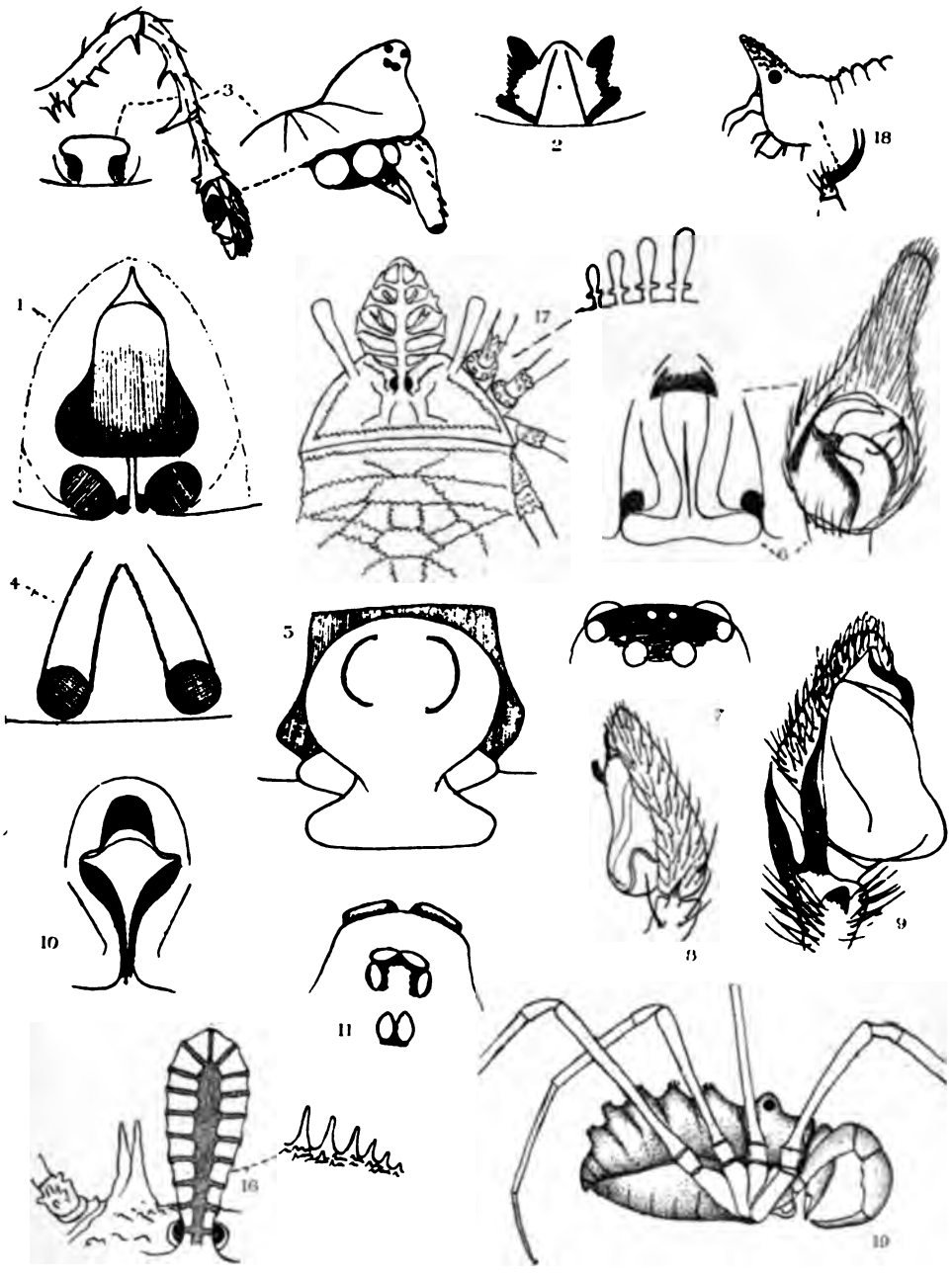
It can be easily distinguished by the shape of shield and armature of coxæ.

**Ixodes hexagonus** *Leach.* Trans. Linn. Soc. London, XI, 1815, p. 397.

Two females from Santa Clara County, and males from Palo Alto (Baker) and Mt. Shasta (Lembert). The shield is more nearly round than figured for European specimens, but the coxal armature is the same.

## EXPLANATION OF PLATE XXXVIII.

Fig. 1. Zelotes femoralis.
Fig. 2. Gayenna californica.
Fig. 3. Erigone californica.
Fig. 4. Cybæus minor.
Fig. 5. Pardosa californica.
Fig. 6. Lycosa pacifica.
Fig. 7. Dictyolathys californica.
Fig. 8. Drassodes californica.
Fig. 9. Metacyrba similis.
Fig. 10. Gnaphosa californica.
Fig. 11. Leptoneta californica.
Fig. 16. Ortholasma rugosa.
Fig. 17. Dendrolasma mirabilis.
Fig. 18. Sitalces californica.
Fig. 19. Protolophus tuberculatus.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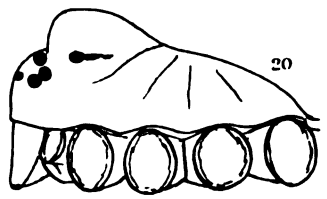
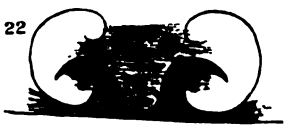
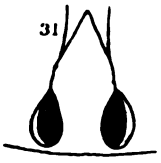
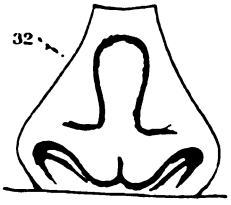
## EXPLANATION OF PLATE XXXIX.

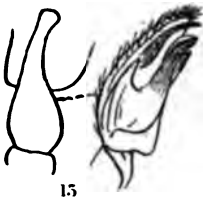
Fig. 13. Pirata californica.
Fig. 14. Pœcilochroa pacifica.
Fig. 15. Zelotes pacifica.
Fig. 20. Lophocarenum fasciatum.
Fig. 21. Lophocarenum fasciatum.
Fig. 22. Dictynina pallida.
Fig. 23. Euryopis californica.
Fig. 24. Lophocarenum fasciatum.
Fig. 25. Herpyllus validus.
Fig. 26. Philodromus mœstus.
Fig. 27. Xysticus californica.
Fig. 28. Drassodes californica.
Fig. 29. Herpyllus validus.
Fig. 30. Philodromus mœstus.
Fig. 31. Epiblemum palpalis.
Fig. 32. Pardosa atromedia.
Fig. 33. Drassinella modesta.
Fig. 34. Theridium californicum.
Fig. 35. Uloborus californicus.
Fig. 36. Euryopis californica.
Fig. 37. Pellenes pacifica.











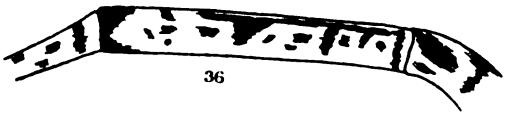



PHOTO-LITH. BRADLEY & RULOFSON, S.F.

## EXPLANATION OF PLATE XL.

Fig. 38. Zelotes maculata.
Fig. 39. Pellenes speciosa.
Fig. 40. Dictyolathys californica.
Fig. 41. Xysticus californicus.
Fig. 42. Dictyna calcarata.
Fig. 43. Herpyllus angustus.
Fig. 44. Cybæus minor.
Fig. 45. Bathyphantes pallidula.
Fig. 46. Dictyolathys californica.
Fig. 47. Trachelas californica.
Fig. 48. Megamyrmecion californicum.

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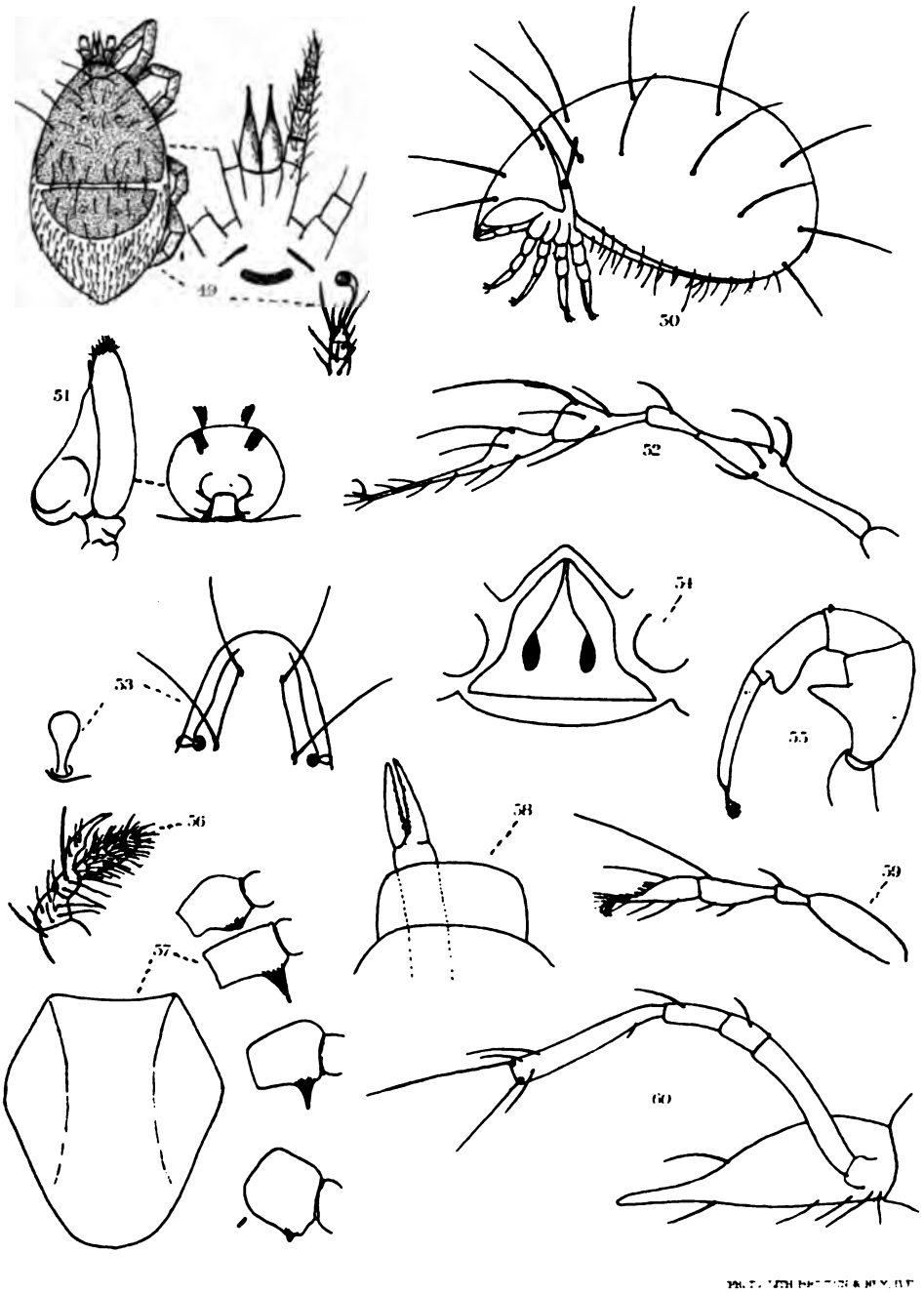
## EXPLANATION OF PLATE XLI.

Fig. 49. Laelaps pilosula.
Fig. 50. Phthiracarus cryptopus.
Fig. 51. Dendryphantes guttatus.
Fig. 52. Oribata californica, leg 1.
Fig. 53. Liacarus modestus, cephalothorax and seta.
Fig. 54. Gamasus californicus, genital plate of female.
Fig. 55. Gamasus californicus, leg II of male.
Fig. 56. Rhyncholophus gracilipes, palpus.
Fig. 57. Ixodes californica, shield and coxæ.
Fig. 58. Gamasus californicus, epistoma and mandible.
Fig. 59. Liacarus modestus, leg 1.
Fig. 60. Bdella californica, beak and palpus.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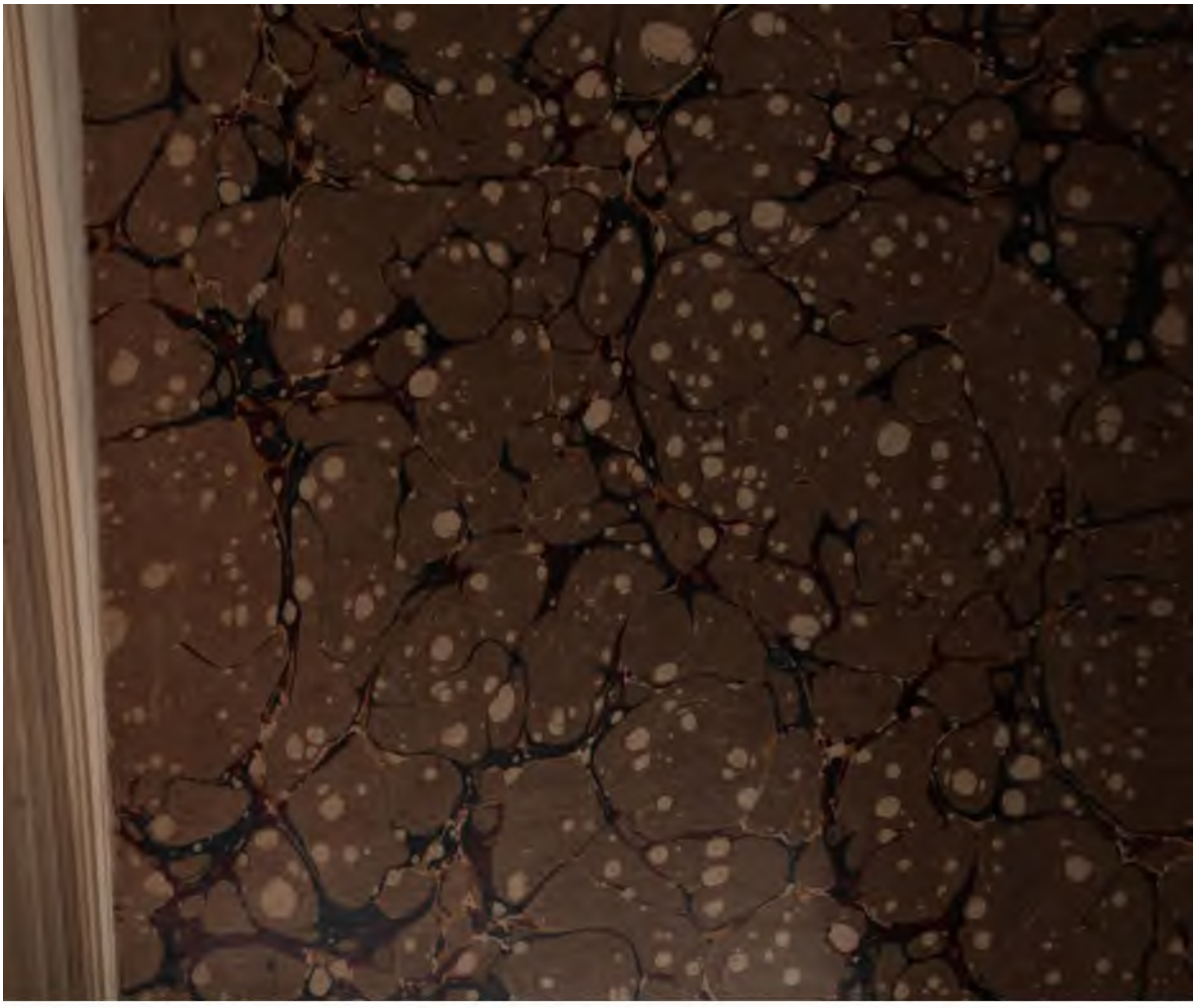
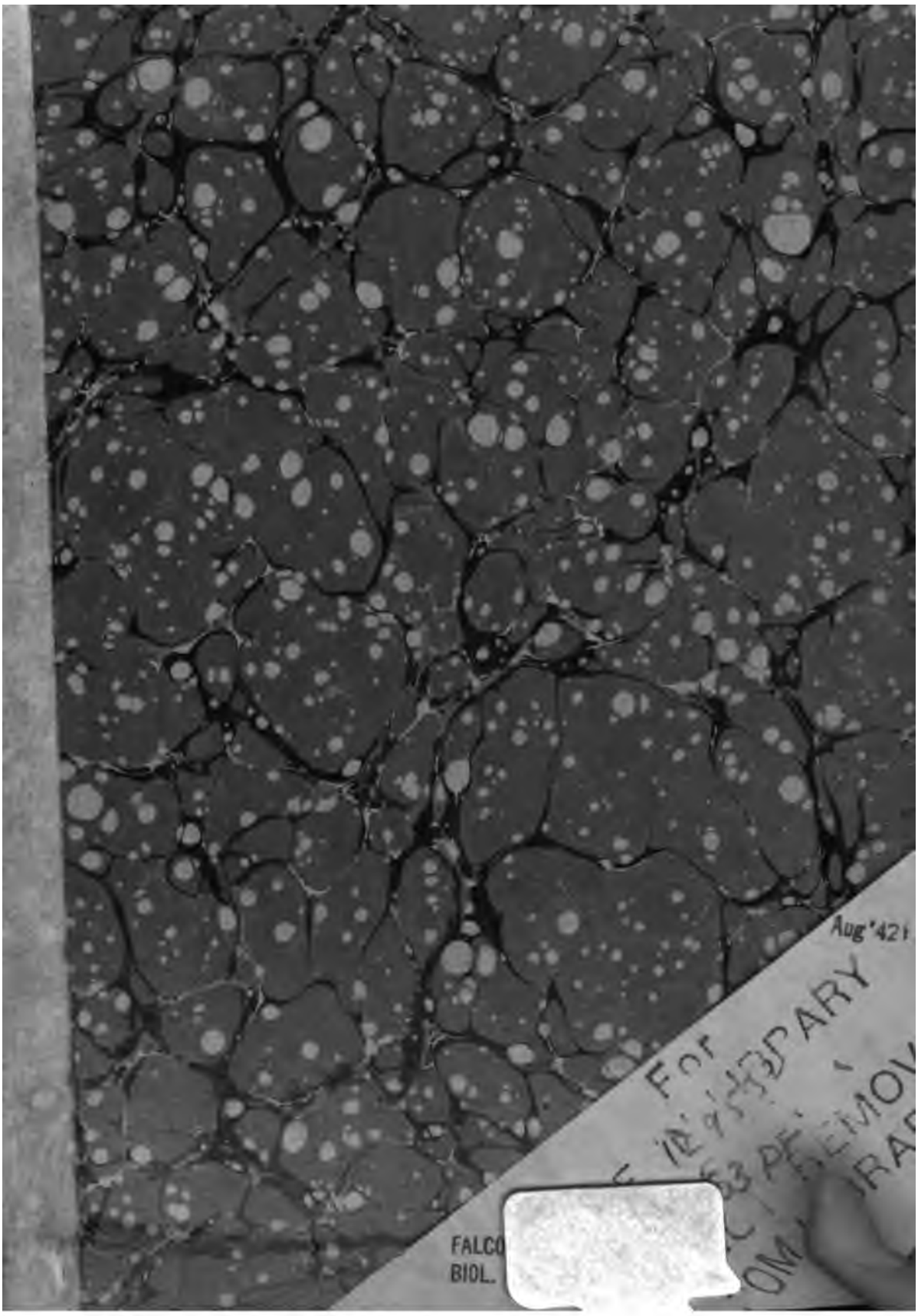
## ERRATA.

Page 118, line 13, for "*Phylline hindorffii*" read *Phylline hendorffii*.
Page 199, line 28, for "*Hapolothrix*" read *Hapalothrix*.
Plate XXVII, for "*Xenochirus infraspinatus*, sp. nov." read *Xeneretmus infraspinatus*, sp. nov.

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